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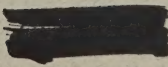
VOL. VIII.

CONTAINING GENERAL AND SPECIAL REPORT OF WORK DONE

FROM JULY 1906 TO JUNE 1907.

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State Geologist and Secretary to Government,
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GENERAL REPORT

OF THE

WORK OF THE DEPARTMENT

From July 1906 to June 1907.

Changes in the Staff and Leave.

Dr. W. F. Smeeth, M.A., D.Sc., &c., who had proceeded on long leave to Europe in May 1905, returned to duty on the 11th December 1906 and resumed charge of his combined appointments of State Geologist and *ex-officio* Secretary to Government, Geological Department, Chief Inspector of Mines and Explosives, and on the same date, Messrs. Wetherell, Bocquet, Slater and Setlur who officiated for Dr. Smeeth in the various posts reverted to their respective permanent appointments.

Mr. E. W. Wetherell, 2nd State Geologist and *ex-officio* Assistant Secretary to Government, was granted privilege leave and furlough from 12th December 1906 and the acting arrangements proposed to fill up the temporary vacancy are still under the consideration of Government.

Mr. P. Sampat Iyengar, M.A., Assistant Geologist, was appointed to officiate as Curator of the Museum and Lecturer in Geology at the Central College with effect from 16th January 1907 *vice* Mr. V. S. Sambasiva Iyer on long leave.

2. The following Officers were on leave at various intervals during the period under report :—

Dr. W. F. Smeeth, M.A., D.Sc., &c., State Geologist and *ex-officio* Secretary to Government, Geological Department, Chief Inspector of Mines and Explosives, on furlough from 1st July to 10th December 1906.

Mr. E. W. Wetherell, A.R.C.S., F.G.S., 2nd State Geologist and *ex-officio* Assistant Secretary to Government, privilege leave and furlough in continuation, from 12th December 1906 to 30th June 1907.

Mr. V. S. Sambasiva Iyer, B.Sc., L.C.E., Curator, Geological Museum, and Lecturer in Geology, Central College, privilege leave and furlough in continuation from 4th December 1906 to 30th June 1907.

Mr. A. T. Setlur, L.C.E., Inspector of Explosives and Mining Surveyor, on privilege leave for two months from 30th April to 29th June 1907.

Secretariat and Office Work.

There was a marked increase in the correspondence during the period under report as compared with the previous year. The following statement shows the number of communications received and despatched at the Head office and the Inspector of Mines' office on the Kolar Gold Field :—

Year	RECEIVED			DESPATCHED		
	Head office	Kolar Gold Field office	Total	Head office	Kolar Gold Field office	Total
1905-06 . . .	4,484	2,135	6,619	3,844	2,850	6,694
1906-07 ...	4,577	3,065	7,642	3,959	3,460	7,419

In addition to the above, there was the usual amount of miscellaneous work, such as typing of general and special reports, upkeep of registers, etc. Much extra work devolved upon the head

quarter staff in consequence of the large number of applications for mining rights which were received and disposed of during the year and the various members of the staff have readily responded to the demands made upon them.

The work of the Draughtsman was particularly heavy owing to the large number of plans and maps required for prospecting licenses and the preparation of Geological maps for some reports now awaiting publication has been delayed in consequence. At the close of the year an additional Draughtsman was taken to assist in the work and the continuance of his services will be formally applied for.

Mining and Prospecting.

The past year has been one of considerable activity owing chiefly to the rapid increases of prospecting work for minerals. For several years, from 1898 to 1904, prospecting work over new ground was practically at a standstill as the issue of licenses and leases was withheld in consequence of the revision of the rules for the grant of same.

2. LEASES AND LICENSES GRANTED.

The revised rules for the grant of Mining Leases and Prospecting and Exploring Licenses were published in March 1904, and from that date to the end of June 1907, the following leases and licenses have been granted :—

Mining Leases	...	...	...	...	10
Prospecting Licenses	...	...	...	...	186
Exploring Licenses	...	...	...	...	85
Licenses for the collection of corundum, asbestos					
and mica	...	...	...	...	12

Of the above, the following were issued during the year 1906-07--

Mining Leases	...	...	...	...	2
Prospecting Licenses	...	...	...	...	130
Exploring Licenses	...	...	...	...	71
Collecting Licenses	...	...	...	...	2

and in addition, 42 existing prospecting licenses were renewed.

3. OUTPUT OF METALS AND MINERALS AND ROYALTY.

Gold.—The following table shows the output and value of gold during the calendar year 1906 and during the six months from January to June 1907, compared with the figures for the preceding year:—

			Weight Ozs.			Value Rs.		
1906 ...	...	...	565,207	14	2	...	3,25,14,540	0 10
1905 ...	...	...	616,758	4	5	...	3,54,51,857	9 0
Decrease			...	51,550	10	3	...	29,37,317 8 2
January to June 1907	...	...	256,137	12	3	...	1,50,31,386	0 0 (approximate)
January to June 1906	...	...	285,973	8	16	...	1,65,11,383	0 0
Decrease			...	29,835	16	13	...	14,79,997 0 0

The whole of this output was obtained from the Kolar Gold Field with the exception of 171 ozs., valued at Rs. 9,620, which was obtained from the Woolagiri Mine during the year 1906-07.

The Royalty due on the gold won during the year 1906-07 is Rs. 15,53,526, compared with Rs. 17,16,513 for 1905-06, being a decrease of Rs. 1,62,987.

The decrease is chiefly due to the diminished returns from the Champion Reef Mine which, at the beginning of 1906, was the largest producer on the Kolar Field and during the past 18 months has been obliged to reduce its output by nearly 40 per cent. This is undoubtedly a matter for regret, but is not, in the opinion of Government, a cause for serious alarm. The remarkable steadiness in the increase of gold from the Kolar Mines may well have given rise to the impression that an extensive body of ore of fairly consistent value was being worked and that the output depended essentially on the facilities for opening and treating the auriferous material. This result has however only been attained by careful foresight and management combined with a certain amount of good fortune and the actual conditions of work are anything but uniform. The valuable ore bodies consist mainly of distinct patches, some of

which are decreasing while others are increasing in value as the mines get deeper and the economic position of a mine at any moment depends on the number of these ore bodies known to exist and on whether they are increasing or decreasing in value. The fall in the production of Champion Reef is due to the number of ore bodies which have more or less simultaneously decreased in value at the depth now reached ; but there is no reason to think that the limits of the zone of payable ore has been reached or that ore bodies of increasing value will not be found at greater depth. Apart from the very gratifying position of the Mysore Mine which is adjacent to Champion Reef, there is both instruction and comfort to be derived from a study of the progress of the former during recent years. A few years ago the main workings of the Mysore Mine passed through a very extensive zone of poor ore ; but now the deepest workings in the Ribblesdale's section have again got into rich ore and the very satisfactory finds at the bottom of Edgar's Shaft, at the deepest and most westerly point on the Champion Lode, which have just been announced, show that the rich ore continues in depth for a considerable distance. The fact that the poor zone of ore that was passed through did not cause a slump in the production of the mine must be largely attributed to the timely discovery of rich ore in another part of the property, *viz.*, Tennant's Section—a stroke of fortune which has not been paralleled in the case of the Champion Reef Mine at the present juncture.

With regard to the smaller mines it is noted with regret that the Coromandel Mine has practically closed down and that the Tank Mine is about to do so. These mines have never been large producers and cessation of work will not very materially affect the total output, but it is a matter for regret and sympathy that those who have spent their money and energy on the development of these properties should have met with so little success.

No gold mines other than those of the Kolar Field are at present adding to the production of the State with the exception of the Woolagiri Mine near Nanjangud which has produced 171 ozs. from some experimental crushings in the course of prospecting and development work. It is satisfactory to note that vigorous prospecting

for gold is now being carried on in several localities, of which mention may be made of the Bellara, Ajjanhalli and Woddarhalli Blocks in the Tumkur District, the Jowanhalli Block in the Chitaldrug District, the Honnehatti and the Tambdihalli Blocks in the Shimoga District, the Nandi Hoshalli and connected Blocks and the Devrukal Block in the Kadur District and the Hunjankere Block in the Mysore District. On several of these blocks there are promising prospects, though none have as yet reached a producing stage.

Manganese.—Increasing attention has been paid to prospecting for manganese ores during the year and many fresh deposits have been discovered. The rush for manganese lands has been encouraged by the success of the shipments of ore from the Shimoga District in the early part of 1906 and by the increase in the prices offered during the past year. In the early part of 1906, a company called the Mysore Manganese Company, Limited, was formed for the purpose of developing certain blocks in the Shimoga District and as this Company was the pioneer of an industry new to the State, Government decided to withhold the issue of further licenses in the Shimoga District until the conditions under which the mineral could be successfully worked were clearly recognized. In December 1906 this restriction was limited to an area of 13 miles round Ayanur and the remainder of the Shimoga District was thrown open to prospectors and a large number of fresh licenses issued. At the same time it was decided to permit manganese to be mined under prospecting licenses for a period of three years without insisting on mining leases being taken out as provided for by the General Rules of 1904, which were primarily intended for gold mining.

Further consideration of the matter has shown that where actual mining operations have to be undertaken involving the expenditure of considerable amounts of capital, the issue of long period leases will be desirable and that on the other hand the tying up of large areas under prospecting licenses is undesirable in the interests of prospectors in general. It is under contemplation therefore to provide for the issue of suitable leases for manganese mining and to set free as far as possible the large areas now held

under prospecting licenses and which are not actually required for mining purposes.

The following statement shows the approximate quantities and value of manganese ore already obtained :—

Year			Ore obtained, long tons	Ore sold, long tons	Value, Rs.	Royalty, Rs.
1905-06	...	...	20,278	15,050	3,21,185	5,643
1906-07	...	...	63,181	50,247	10,37,901	20,209
Total ...			83,459	65,297	13,59,086	25,852

Chrome.—A number of licenses for working the various deposits of chrome ore which have from time to time been located are now in existence and prospecting operations are in progress on several blocks. Considerable quantities of a good quality of chrome ore have been found between Mysore and Nanjangud in connection with magnesite deposits. Some 10,000 tons of ore have already been collected, but none have as yet been exported.

In the Hassan District, a long run of chrome-bearing rocks is being prospected and large quantities of a rather low grade ore have been located. This ore will require concentration for export purposes and an experimental plant for effecting this is in course of erection near Tagadur, the results of which will be watched with interest.

More detailed notes as to the progress of mining and prospecting will be found in the Report of the Chief Inspector of Mines for the year 1906-07, which is now in the Press.

Inspection of Mines.

The average number of persons employed in the mining industry during 1906 was 34,064 compared with 30,328 during 1905.

The total number of fatal and serious accidents was 399, resulting in the death of 70 persons and serious injury to 373. The corresponding figures for 1905 were 252, 76 and 249, respectively.

The death rate per 1,000 persons employed during 1906 was 2·05 as against 2·51 during 1905. The reduction in the death rate is chiefly due to the inclusion this year of persons working in the Manganese and Chrome Mines as the work is at present carried on at comparatively shallow depths. The death rate per 1,000 persons employed in Gold Mines was 2·31 as against 2·51 during 1905.

For certificates of employees under the Mines Regulation, 551 men were passed for Blasters' Certificates and 614 for Mestris' Certificates.

Inspection of Explosives.

The total number of licenses issued for the manufacture, possession and sale of explosives in the Mysore State during the year 1906 was 163 against 140 during the year 1905.

The number of inspections of licensed premises made by the officers empowered to do so was 348 in 1906 against 315 in 1905.

The total number of accidents from explosives was 17, resulting in the death of 10 persons and serious injury to 21; the corresponding figures for 1905 were 13, 11 and 25.

The total number of cases dealt with during the year 1906 under the Explosives Regulation for illegal possession of explosives was 19, involving 25 persons, of which 14 cases resulted in the conviction of the accused.

An explosion of a gun-powder store belonging to the Public Works Department at Kunikere in the Hiriyur Taluk, which was attended with a loss of 10 lives, occurred on the 10th of May 1906, and in this connection Government considered it desirable that the exemption from inspection by the Chief Inspector of Explosives in Mysore which had been allowed in the case of the explosives magazines and stores under the management and control of the Public Works Department should be withdrawn, and have therefore ordered in their Proceedings No. J. 1038-47—Police 179-05-2, dated 29th October 1906, that all magazines and stores of explosives and all places where explosives are manufactured shall, without any exception, be subject to inspection by the Chief Inspector of Explosives.

The Annual Report of the Chief Inspector of Explosives in Mysore for 1905 was published during the year.

Geological Survey.

During the year under report about 2,000 square miles of country have been surveyed and mapped. This includes some 750 square miles in the taluks of Sorab and Shikarpur in the Shimoga District; 270 square miles in the taluks of Mandya and Malvalli, about 800 square miles in the taluks of Nanjangud, Gundlupet and Chamrajnagar in the Mysore District. Also a preliminary traverse was made across parts of the Hassan and Kadur Districts from Banavar to the Bhund Ghat *via* Belur and Mudgere and notes on several prospecting blocks in various parts of the State have been prepared and recorded.

The information already collected by the Department has been largely made use of by prospecting parties who have in many cases asked for and received the advice and assistance of the Survey Officers. Detailed reports of the major portion of the survey work are published in Part II of this Volume and the following is a brief summary of the more important features.

TRAVERSE FROM BANAVAR TO THE BHUND GHAT.

This traverse was made by Mr. Sampat Iyengar, Assistant Geologist, in December and January and his report will be deferred until the next Volume of the records so as to connect it with further work in the same area. In the meantime, Mr Sampat Iyengar has furnished the following *ad interim* note :—

“In December 1906 and January 1907, a rapid traverse was made by me from Banavar to Bhund Ghat *via* Belur and Mudgere with the intention of obtaining a general idea of the nature and run of the rocks met with in the area. The region, all along the road section, is gneiss with several thin caught-up runs of fine grained hornblende schist at Jyavgal and Kotigenhalli, and of amphibolites converted to potstone near Halebid. The gneiss at Mudgere is highly fissile and has biotite mica largely developed along divisional planes. Pegmatite veins invade the gneiss in this locality and these contain numerous small books of muscovite mica. At the road

crossing of the Hemavati near Banakal, Mudgere Taluk, the gneiss on the right bank of the river is altered into variegated mottled pink, yellow, and white tinted kaolin for a depth of over 30 feet.

“West and north west of Bhund Ghat, the Mudgere gneiss has invaded the area from below and has elevated irregularly the massive fine grained hornblende schist trap flows of the Kudremukh and Ballalrayandurga ridge which at present form the bold southern escarpment of the Sahyadri range fronting the South Canara plain. The presence of gneiss in the Durgadhalli and Netravati valley and the dipping away of the hornblende schist in all directions from the gneiss can be accounted for by the rapid differential erosion of the several dome-shaped masses of hornblende schist and the underlying gneiss. The marked columnar jointing of the hornblendic trap flow constituting the table land of Mysore at Bellalrayandurga and Bangarbelige ridges, has given rise to tabular ledges, and also to perpendicular faces owing to the falling away of slices of the rock along lines of vertical joints.

“At contact with gneiss the hornblende schist has developed large pink garnets near Durgadhalli and Sampigekan. Owing to the humid atmosphere, the dark hornblende schist is converted to a reddish brown gritty material which often can be mistaken for a grit or sandstone.

“The potstone used in the construction of the temples at Halebid and its vicinity appears to have come from the several large old workings to be found south and east of Halebid. There is still a large quantity of potstone round about the town, but the quality is inferior.”

Mr. Sampat Iyengar was engaged as Lecturer at the Central College for the remainder of the year, but was able to utilize the summer vacation in examining a small area around Dod Guni in the Tumkur District which connects with work previously done by him and reported upon in Volume VII of the Records, page 27, and Plate III.

Mr. Sampat Iyengar has furnished me with the following brief note on this work :—

"I made use of the vacation period in proceeding to Dod Guni area (Tumkur District) and mapped as per instructions the country round about. The principal rock met with here was hornblende schist with fine grained, coarse, and amygdular varieties. Overlying this hornblende schist unconformably were the chloritic schists and clayey schists (3rd formation). The last mentioned rocks contain nodules of manganese and iron ores, as was the case in the Chitaldrug District. While at Dod Guni, I inspected the several Manganese Mines worked in the region, and made some suggestions regarding the localities in which manganese, &c., might be looked for."

Mysore District—About 800 square miles of the Mysore District in the south-east corner of the State was surveyed and mapped by Mr. Jayaram, Assistant Geologist, during the past season. His report on this work will be found in Part II and it is accompanied by a sketch map (Plate III) on a scale of 4 miles to an inch. The broader features of the area are comparatively simple, the eastern portion being composed of charnockite and the central and western portions occupied by the older granitic gneisses with inclusions of hornblendic schists and penetrated by dyke rocks of various kinds. On the other hand, any attempt to survey the area in detail presents very great difficulty partly on account of the heavy jungle which covers the hilly portions and of the large amount of soil and cultivation in the lower lying tracts and partly on account of the large number of small exposures of rocks which may bear considerable resemblance to one another although their origin and past history may be dissimilar.

The oldest rocks in this area appear to be the hornblendic schists as has been found to be the case in several other parts of the State, notably in the Kolar District, and it will probably be correct to assume that these small patches of hornblende schist are of similar age and origin to the schists of the Kolar Belt and that they once formed part of a widely extended series of basic lava flows for which I have adopted the name of the Kolar Series. One of the principal patches of these schists is the small band in the neighbourhood of Valgere (Woolagiri), but several others of appreciable size have been mapped and noted on by Mr. Jayaram and the

smaller inclusions scattered throughout the gneiss are innumerable and cannot be mapped. These patches and inclusions of schist afford evidence of having been intruded by or caught up in the old gneissic granite which is the most widely distributed rock in this area. The gneissic granite however varies much in texture and appearance from point to point and, apart from such pegmatite and aplite bands and veins which may have belonged to the later stages of the intrusion of the gneissic granite itself, there is no doubt that the whole complex has been intruded by granites of later age which cannot always be distinguished from the gneiss. Owing to this, mere contact effects and evidences of granitic intrusion do not always enable us to assign a hornblendic mass to the age of the Kolar Schists, especially in view of the fact that intrusions of hornblendic material which sometimes have a schistose character are known to have taken place subsequently to the formation of the main mass of the gneissic granite. The difficulty of distinguishing between these two classes of hornblendic material is further increased by the fact that both are frequently granulitic in texture, this texture being very probably largely original in the case of the later intrusive dykes and masses while it appears to be essentially secondary in the case of the older lava flows and due to recrystallization under the influence of the intruding granitic gneiss. Mr. Jayaram has mapped and differentiated a large number of outcrops of which some undoubtedly belong to the age of the Kolar Schists, (*i. e.*, prior to the gneiss) while others are certainly intrusive into the gneiss though they may be much squeezed, broken up or intruded by later emanations. On the other hand, a great many of the outcrops remain doubtful especially where their boundaries and contacts are obscured and the problem is further complicated by the appearance of dykes and lenses which appear to be related to the basic members of the charnockite series.

The main mass of the charnockites run up the east side of the Mysore District as shown on Plate III where they form the high ridges of the Biligirirangan Hills and extend northwards across the Cauvery river near Sivasamudram. To the south these rocks appear to join up with the great massif of the Nilgiris where they

have been described by Mr. Holland.* The boundary between the gneiss of the Mysore District and the eastern charnockites lies somewhere near the foot of the Biligirirangans, but the junction is for the most part obscured by soil and jungle. Mr. Jayaram's work shows that there are lenses and branching bands of charnockite lying in the gneiss and there can be no doubt that the former is younger than the latter and intrusive with regard to it.

The junction between the gneiss and the charnockite of the Nilgiris lies somewhere to the south of the boundary of the State which is here formed by the Moyar river and the map shows that the strike of the gneiss and of its associated inclusions tends to follow the boundaries of the great charnockite masses being more or less north and south to the west of the Biligirirangans and bending round to nearly east and west along the Moyar valley to the north of the Nilgiris. There are also some lenses of the older gneiss included in the mass of the charnockite; one of which in the neighbourhood of Badavadi was found to contain ruby corundum. The quantity of this mineral does not appear to be large, but several bags of loose crystals were removed from this spot some years ago by Mr. Randolph Morris.

Mr. Jayaram has also noted the occurrence of dykes and lenticular masses of basic hypersthene-bearing rocks in the main mass of the gneiss and these appear sometimes to be oblique to the foliation strike of the gneiss. They are regarded as intrusions of the more basic members of the charnockite series or at any rate associated with the latter and are more recent than the gneiss and its inclusions of hornblende schist and granulite. Further some hornblendic rocks have been found which in several respects resemble these basic charnockite intrusions, but which do not contain hypersthene. They do not appear to correspond exactly to any of the other petrological types and Mr. Jayaram has noted their occurrence under the head of quasi-charnockites as a temporary designation pending further investigation.

* Records of the Geological Survey of India, Vol. XXX.

A few miles to the north-west of Nanjangud some ultrabasic rocks are found in the gneiss. Some of these are of the nature of Dunite which has been considerably altered and is now very freely veined with magnesite and contains deposits of chromite. Some of these masses are in the form of long runs parallel to the foliation of the gneiss, while others are more or less oval patches or bosses and it is by no means clear whether they are intrusive into the gneiss or are inclusions of older rocks in the gneiss. The extensive veining with magnesite resulting from decomposition of the olivine is rather suggestive of metamorphism under the influence of igneous emanations and the long thin vein-like formation in which the chromite occurs is to my mind more in keeping with the theory of subsequent segregation and vein formation than with the more usual theory of the formation of masses of chromite by means of original magmatic segregation in an intrusive mass. A more detailed study of these rocks than I was able to afford during my brief inspection would no doubt throw some light on these points. There are also in the same neighbourhood some ultrabasic rocks which have been converted into potstone and some at least of these appear to have been dykes intruded into the gneiss.

On the whole the area covered by Mr. Jayaram's report is an extremely interesting one from a petrological point of view, but a great deal of careful work will be required before the various rock-types can be correlated and their proper sequence assigned to with any degree of certainty.

Shimoga District.—Survey work in the Shimoga District was carried on by Mr. H. K. Slater, Assistant Geologist, and an area of about 750 square miles was examined and mapped comprising nearly the whole of the Sorab Taluk and the south-western portion of the Shikarpur Taluk, thus practically completing the preliminary survey of the north-western corner of the Shimoga District. As I did not have an opportunity of inspecting any of this work I will not offer any comments on it at present. For details a reference may be made to Mr. Slater's report in Part II of this Volume and to the map which accompanies the report. The portion of the Shikarpur Taluk examined and the eastern side of

the Sorab Taluk are apparently geologically very similar to the parts of Shikarpur previously reported by Mr. Slater.

The very large number of slag heaps and the numerous pits from which iron ore appears to have been derived are evidences of a wide spread iron smelting industry in the past.

Numerous other pits and old workings are referred to by Mr. Slater some of which he thinks may have been for gold, but no direct evidence of the occurrence of auriferous deposits has been recorded. Manganese ores were found in several places, but they do not appear to be in large quantities or of good quality. Nearly the whole of the western portion of the area is covered by laterite which is found in many places to be underlain by lithomargic clays.

Mr. Slater offers many suggestions as to the origin of these deposits some of which are difficult to follow or accept. The lithomargic clays are considered to represent the decomposed residue of a felspathic rock *in situ*, while silicified portions of the lithomarges are stated to be of probably the same origin as some of the hæmatite quartzites. On the other hand it is stated that some portions of the lithomarge may have been derived from magnetite quartzite which appears to me to be a random suggestion unlikely to be maintained on further consideration. The laterite which occupies so large an area in the Sorab Taluk is shown to vary considerably in character and various modes of origin are suggested in the report rather than explained or described. A "high level" laterite is regarded as derived from a ferrugineous mud lava while what is called the low level laterite is supposed to be formed from the disintegration of such rocks as lithomarge, magnetite quartzite and pseudo greywacke. Again, certain portions of the laterite are supposed to be due to the simple alteration *in situ* of the lithomarge. Whatever truth there may be in any or all of these suggestions, there is no attempted explanation of any of the processes followed which would enable one to judge of their probability and although it is no doubt true that lateritic material has been formed in various ways, some general appreciation of the conditions which led to the formation of extensive spreads of laterite at an apparently definite epoch is still required.

IRON ORES NEAR SIVASAMUDRAM.

Towards the close of the season I sent Mr. Slater to make a rapid survey of part of the Malvalli Taluk to the north and north-east of Sivasamudram for the purpose of investigating the reported occurrence of iron ore.

Some time ago part of this area was examined by Messrs. Wetherell and Jayaram and they reported that such iron ores as existed were either in small quantities or comparatively poor in quality. Unfortunately the field maps made by these officers have been lost or mislaid. Mr. Slater's work is therefore supplementary to the above and embraces some fresh ground to the east of the Shimsha river. His report and a sketch map will be found in Part II of the present volume.

The country is composed of gneiss penetrated by tongues of charnockite both being penetrated by the more recent Closepet granite which lies on the east side of the area examined and stretches in a wide belt far up the country to the north.

The charnockite outcrops are the terminal extension of the large masses which form the Nilgiri and Biligirirangan hills further to the south. They belong to the acid and intermediate types of the series, the former largely predominating. Associated with the intermediate types are bands or layers of garnetiferous pyroxene granulite containing magnetite and of quartz-hypersthene rocks containing a good deal of magnetite. Both of these classes of rocks may be regarded as iron ores and they were undoubtedly so regarded by the ancients who worked them by means of shallow pits many of which are still discernible. As they are low grade ores and as it is practically certain that the ancient smelters used nothing but high grade material, the workings afford evidence that the art of crushing and concentrating this material was understood and applied in ancient times. This evidence goes to show that there cannot have been any large quantity of high grade ore available in the neighbourhood or the native workers would not have gone to the trouble of crushing and concentrating these poorer materials, unless of course they could obtain thereby a product which was more easily smelted in their

furnaces. This however cannot have been the case, for the product obtained was magnetite in the shape of dust or fine sand which cannot have been an easy material to smelt and would not have been selected had a rich ore in any other form been available.

This view is borne out by the results of survey so far accomplished, for the occurrences of high grade ore are few and far between and the amount available comparatively insignificant. The visions conjured up by popular fancy of inexhaustible supplies of rich ore waiting to be smelted by electricity derived from an almost equally unlimited Cauvery river at a cost of next to nothing must therefore, I fear, be seriously modified if not altogether abandoned. Just as the ores so far discovered are for the most part low grade, involving considerable expense in mining and concentrating before a product suitable for smelting could be obtained, so the steady water power available at the Cauvery Falls is comparatively speaking small and is at present entirely absorbed at far more remunerative rates than any smelting process could afford. To increase the power supply storage on a large scale is necessary and this means expense and increased cost for the power supplied.

The problem of utilizing these ores depends therefore on the satisfactory development of electric smelting of iron, on the provision of a water storage for the generation of electricity at a sufficiently moderate price per unit and on the expense of mining and preparing the ore.

With regard to the latter I have already noted that the amount of rich and easily mined ore appears to be small and may for practical purposes be neglected. The largest deposit so far discovered is a vein of magnetite and hæmatite running northwards from the Bluff at Sivasamudram which was originally found by Dr. J. W. Evans and has since been located and followed up. The vein starts about one mile W. N. W. of the Gangana Chukki Falls and runs in the N. N. W. direction for five or six furlongs. It has an average thickness of about one foot and does not appear to extend for more than a few feet in depth. In composition it contains $\text{FeO}=18.78$ per cent; $\text{Fe}_2\text{O}_3=63.37$ per cent; the total Fe being about 57 per cent and is therefore of fairly high grade though not

particularly so as such materials go. The total quantity is obviously small and is not likely to be more than 1,000 tons or so. Some other small veins are rather richer in iron, but of much smaller dimensions.

For possible large quantities of ore we have therefore to look to the runs of hypersthene quartz magnetite rock which are described by Mr. Slater as occurring to the East of the Shamsha river and South of Halagur.

These runs, of which there appears to be several parallel outcrops, extend North and South for several miles.

Mr. Slater has made some rough separations of the magnetite by means of a magnet most of which give results which are too high owing to the presence of other magnetic minerals.

A more carefully treated sample gave about 55 per cent of magnetic residue the greater portion of which is magnetite and which was found to contain 66 per cent of iron.

A good deal of prospecting work would be necessary before the average value of large quantities of these ores could be estimated, but from a brief inspection of some of the outcrops which I made in company with Mr. Slater, I should judge that the above mentioned result is too high and that in all probability the average grade which could be obtained would not exceed 40 per cent of magnetic concentrate. This means that for each ton of concentrate suitable for smelting purposes $2\frac{1}{2}$ tons of ore would have to be mined, crushed and concentrated, thus materially augmenting the cost of the material supplied to the furnaces. Further investigation is required before an estimate can be made of what this cost would be, but the facts already noted appear to me to completely negative the popular tradition or assumption that we have in the neighbourhood of the Cauvery Falls abundant supplies of rich ore obtainable at a low cost.

Prospecting Blocks.

Sundry geological notes on prospecting blocks which were visited during the year have been recorded in the Report of the Chief Inspector of Mines for 1906-07 and need not be repeated

here. The following list of the blocks referred to is given for reference.

- | | | |
|--------------------------------------|-----|---|
| (a) Kolar District | ... | (i) East Betarayaswami Block. |
| | | (ii) Ahmed's Block. |
| (b) Bangalore District | ... | (i) Karlapur Block (No. 58). |
| (c) Tumkur and Chitaldrug Districts. | | (i) Bukkapatna and Bellara Blocks (leases 105 and 106). |
| | | (ii) Bellara Prospecting Block (No. 6). |
| | | (iii) Hallenhalli Block (No. 8). |
| | | (iv) Nerlagudda Block (No. 7) and Pura Block (No. 9). |
| | | (v) Ramenhalli Block (No. 24), Javanhalli Block (No. 10) and Anesidri Block (No. 90). |
| | | (vi) Dindivara Block (No. 128). |
| | | (vii) Turavanur Block (No. 11). |
| (d) Hassan District | ... | (i) Gollarhalli Block (lease No. 89). |
| | | (ii) Biranhalli Block (No. 23). |
| (e) Shimoga and Kadur Districts. | | (i) Hiriyur Block (No. 138). |
| | | (ii) Honnehatti Block (No. 29). |
| | | (iii) Bilikalbetta Block (No. 127). |
| | | (iv) Lakvalli Block (No. 39). |
| | | (v) Jalagargundi Block (No. 40). |
| | | (vi) Nandi Block (No. 64). |
| | | (vii) Rajanhalli Block (No. 77). |
| | | (viii) Sakrebail Block (No. 80). |
| | | (ix) Devrukal Block (No. 12). |
| (f) Mysore District | ... | (i) Woolagiri Mining Block (lease No. 21). |
| | | (ii) Hunjankere Block (lease No. 70). |
| (g) Anantapur Gold Field. | ... | ... |

Library.

Several important journals and periodicals connected with Geology and Mining have been received in exchange for the publications of this department from numerous Scientific Societies in the different parts of the world and special treatises on Spectroscopi

analysis and a few standard books on Mining have also been purchased for the Department.

Laboratory.

One hundred and eight assays and analyses were made at the Chemical Laboratory both for the Department and for the public, of which 66 were for gold and the rest for various metals, chiefly Manganese and Chromium. About 40 determinations of minerals were also made for the public at the Geological Office.

Museum.

The very limited and unsuitable accommodation at the Geological Office can hardly be described as a Museum and the lack of proper accommodation for the collections, storage and exhibition of the rocks and minerals of the State has been of the greatest disadvantage for several years past. It is not too much to say that a good deal of money which has been spent on Geological Survey has been wasted and that the results are far less precise and accessible than would have been the case had a Museum been provided. This is particularly unfortunate in view of the keen interest which has been taken in prospecting work during the past year or two and for the sake of the large number of prospectors who are seeking information about the rocks and minerals of the State and to whom well arranged collections and exhibits would be most useful. Until some suitable accommodation for specimens is provided, the Survey work must remain inefficient and very unsatisfactory.

Geological Lectures.

The Geological Lectures at the Central College were carried on as usual and four candidates passed the B. A. Examination at the close of 1906. During the year six Geology Graduates have obtained employment with Mining and Prospecting companies and several scholarships have been granted by Government to others who have been attached to the Geological Department for the purpose of receiving training in Mining and Geological Survey work.

Owing to the absence of Mr. Sambasiva Iyer on leave, the lectures at the Central College were given by Mr. Sampat Iyengar from the 16th January 1907 to the close of the year.

Owing to the delay experienced in obtaining Government sanction for the grant for the annual geological excursion, the present year batch of students were deprived of the benefit of the usual excursion trip within and outside the Province and Mr. Sampat Iyengar devoted the period of the summer vacation to survey work in the Dod Guni area of the Tumkur District.

W. F. SMEETH,

BANGALORE, }
August 1907. }

*State Geologist and Secretary to
Government, Geological Department.*

APPENDIX.

Additions to the Library during the period from July 1906 to June 1907.

- Transactions of the American Institute of Mining Engineers, Bi-monthly
Bulletins Nos. 10, 11 and 12 for July, September and November
1906 and Nos. 13 and 14 for January and March 1907.
- Rock excavation, Methods and Cost, by Gillette.
- Accidents in Mines, by Sawyer.
- Mineral Industry—1905—Volume XIV.
- Studies in Micropetrography—Vol. I, Parts 1, 2 and 3, by E. Howard
Adye.
- Exner—Haschek, Wellenlangen—Tabellen, Erster Teil.
Do do Zweiter Teil.
- Exner—Haschek, Wellenlangen—Tabellen, Der Bogenspektren Vols. I
and II.
- Weinschenk, Grundzuge der Gesteins Kunde—Vols. I and II.
- Dr. E. Weinschenk, Auleitung Zum Gebrauch des Polarisations—Micros-
kops.
- Rosenbusch, Physiographic—Bd. I.
- Mineralien—I and II Halfte.
- Eder and Valenta, Spektren Von Kupfer, &c.
- Atlas of Emission Spectra, by Haggénbach and Konen.
- Spectroscopy, by Baly.
- Watts Index of Spectra.
- Weinschenk, Die Gesteinshilden—Mineralien.

Periodicals.

- Betrage Zur Geophysik—VIII Band—1, 2, 3 and 4 Hefts.
- Centralblatt fur Mineralogie, Ge, 24 numbers (bi-weekly).
- Neus Jahrbuch fur Mineralogie, Beilage Bands.
- Nature.
- Mining World.
- Mining Journal.

Australian Mining Standard.
 Engineering and Mining Journal.
 South African Mines.
 Kolar Gold Field News.
 Indian and Eastern Engineer.
 Knowledge and Illustrated Scientific News.
 Mining Magazine.
 Madras Mail.
 Journal of the Transvaal Institute of Mechanical Engineers.

INDIA.

Records of the Geological Survey of India—Vol. XXXIII, Part 4—1906.
 Do do XXXIV, Part 1—1906.
 Do do do 2—1906.
 Do do do 3—1906.
 Do do do 4—1906.
 Do do XXXV, Part 1—1907.
 Do do do 2—1907.
 Memoirs of the Geological Survey of India—Series XV—Vol. V—No. I
 (with plates 1 to 17).
 Memoirs of the Geological Survey of India—Series XV—Vol. V—No. II.
 Do do New Series—Vol. II—No. III.
 Mr. Alex. Rea's Monograph on Stone Carving and Inlaying in Southern
 India.
 Transactions of the Mining and Geological Institute of India—Vol. I,
 Part 4.
 Pamphlet on the Exotic Blocks of the Himalayas, by C. L. Griesbach,
 C. I. E.

UNITED KINGDOM.

Thirtieth Annual Report of His Majesty's Inspector of Explosives for 1905.
 Geological Literature added to the Geological Society's Library during the
 year ended 31st December 1905.
 The effect of Copper in Steel.
 Influence of Silicon, Phosphorus, Manganese and Aluminium on chill in
 Cast Iron.
 The Jubilee of the German Society of Engineers.
 Preliminary Note on the influence of Manganese on Iron.

- The early use of Iron.
 Brittleness and Blisters in thin Steel sheets.
 Compression of Steel Ingots in the Mould.
 Report on the Sixth International Congress for applied Chemistry.
 Use of Oxygen in removing Blast-Furnace obstructions.
 The relation between Type of Fracture and Micro-structure of Steel Test Pieces.
 Chain-making Machinery.
 Solid Rolled Steel Car Wheels and Tyres.
 Volume and Temperature changes during the cooling of Cast Iron.
 The heat treatment of Wire.
 The Preparation of Carbon-free Ferro-manganese.
 Deformation and Fracture in Iron and Steel.
 Influence of the condition of the several varieties of Carbon upon the strength of cast-iron as cast and heat treated.
 Hardness of the constituents of Iron and Steel.
 Quaternary Steels.
 Mines and Quarries—General Report and Statistics—1906.
 Memorandum by the Chief Engineer of the Manchester Steam Users' Association—1905.
 The Anthracitization of Coal, by David Burns.
 Transactions of the North of England Institute of Mining and Mechanical Engineers—
 Volume XLVIII—Parts 1 to 8.
 Volume XLIX--Parts 1 to 6.
 Volume L—Parts 1 to 7.
 Volume LI—Parts 1 to 7.
 Volume LII—Parts 1 to 8.
 Volume LIII—Parts 1 to 5.
 Volume LIV—Parts 1 to 9.
 Volume LV--Parts 1 to 6.
 Volume LVI—Parts 1 to 4.
 Volume LVII—Parts 1 to 3.
 Annual Report of the Institute for 1899-1900.
 Do do 1900-1901.
 Do do 1901-1902.

Annual Report of the Institute for 1902-1903.

Do do 1903-1904.

Do do 1904-1905.

Do do 1905-1906.

Do do 1906-1907.

General and Subject Matter Index to Volumes I to XXXIII—1852-1889.

GERMANY.

Jahrbuch der Koniglich Preudsichen, Geologischen, etc. Band

XXVI—Hefts 1 to 4.

Do do XXVII—Heft 1.

Lehrbuch der Allegemeinen Chimie—1906.

Repertorium Jum Neuen Jahrbuch fur Minerologie, etc., 1900-1904.

PARIS.

Les Etages et les Fannes Du Bassin Tertiare du Piemont.

Sur la valeur stratigraphique des Lepidocyclina et des Miogypsina.

Les Lois Fondamentales de L'orogenic De La Terre.

Fenomeni di Corrunugments Negli Schisti Cristallini Delle Alpi.

NORWAY.

Sundry Geological Problems, by G. Henrikson, Inspector of Mines
Christiania.

ROUMANIA.

Travaux de la Commission du Petrole—Vol. I—1905.

Bulletin de la Societe des Sciences de Bucarest—1904.

Do do 1905.

Extrait des Archives des Sciences Physiques et Naturelles.

Quatrieme Periode T.—XI—Juni 1901.

ITALY.

Processo Termo—Electrico Per ia Riduzione dei Minerali-di Ferro di
Ernesto Stassano.

Present state and future of Thermo-electric Metallurgy generally and
Thermo-electric Siderurgy especially, by Ernesto Stassano.

Essai Schematic—1907, by F. Sacco.

CANADA.

Annual Report of the Geological Survey—1882, 1883 and 1884.

Do do Vol. XIV—1905 (with maps).

Report on Mesozoic Fossils—Vol. I, Part II.
Annual Report, New Series—Vol. VI—1892-93.
Catalogue of Canadian plants—Part IV Endogens.

UNITED STATES.

Lists of New Publications.
Mineral Products of the United States for the Calendar years from 1896 to 1905.

TRANSVAAL.

Half-yearly Report of the Government Mining Engineer for the six months ending 31st December 1905.
Annual Report of the Government Mining Engineer for the year ending 30th June 1906.

NATAL.

Report on the Mining Industry—1905.
Report on the Natal and Middleburg Coals.
Third and Final Annual Report of the Geological Survey of Natal and Zululand.

RHODESIA.

Report of the Secretary for Mines for the year ended 31st March 1906.

WEST AUSTRALIA.

Monthly Mining Statistics, being the supplement to Government Gazette.
Mining Act—1904 and Regulations thereunder.
Bulletins Nos. 21, 22, 23, 24 and 25.

SOUTH AUSTRALIA.

Geological and General Report on the Northern Territory of South Australia for the year ended 30th June 1906.
Official contributions to the Palæontology of South Australia.

QUEENSLAND.

Geological Survey Reports Nos. 201, 203 and 205.
Geological Sketch Map of Queensland.

NEW SOUTH WALES.

Annual Report of the Department of Mines for 1906.

NEW ZEALAND.

Bulletin No. 1—1906.

TASMANIA.

The Progress of the Mineral Industry of Tasmania for the quarter ending
31st March 1906.

Do do 30th June 1906.

Do do 30th September 1906.

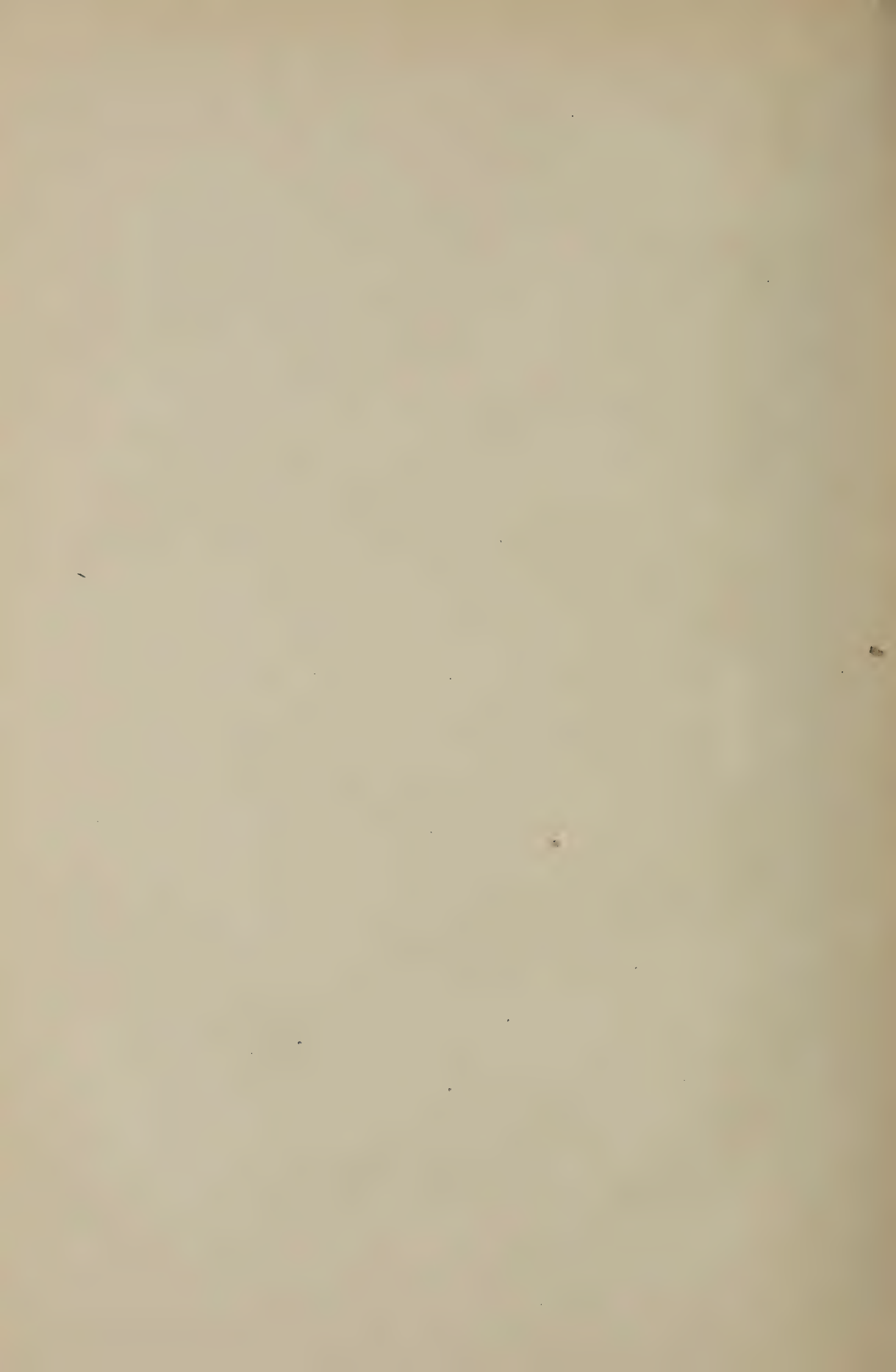
Do do 31st December 1906.

Report on Mathinna Gold Field—Part II.

Report on Cox's Bight Tin Field.

Report on the Renison Bell Tin Field.





PART II.

—◆—
SPECIAL REPORTS.

Report on the Sorab and part of Shikarpur Taluks.

BY H. K. SLATER, F.G.S.,

Assistant Geologist.

The following report on the country geologically surveyed during the first four and a half months of the field season of 1906-07 covers ground the greater portion of which lies immediately to the West of the area which was preliminarily reported on in Records Volume II.

It comprises practically the whole of the Sorab Taluk which forms the extreme N. W. corner of the Shimoga District; and the South Western corner of the Shikarpur Taluk.

Extent and position of area surveyed.

The total area amounts to approximately 750 square miles. A large portion of this ground is covered by a spread of laterite and evergreen forests, the first rendering detailed work unnecessary, and the second, impossible. Economically, the most valuable portion of the area is that lying in the Shikarpur Taluk to the North of Anantapur, as at one time in the history of Mysore this must have been one of the principal centres of iron smelting.

Economical Importance.

Physical Features.

The Sorab Taluk is remarkably free from any physical feature worth mentioning. A few low ridges covered with scrub jungle are found in the Eastern half of the Taluk running in a North-Westerly direction and similar low interrupted ranges of hills running parallel with these are found across the Mysore boundary in the Dharwar District towards Byadgi, on the Southern Maharatta Railway, the intervening country being remarkably flat.

Sorab Taluk.

On the extreme western side of Sorab Taluk lies a small group of hills, the central mass of which is composed of quartz syenite.

The principal feature here is the imposing hill of Chandragutti with its connected spurs, dwarfing in its grandure all around it. The hill itself is covered with jungle, mostly bamboo; the only portions free from it are the smooth steep faces of solid rock. Surrounding the hill run three lines of fortification, in semi ruin.

From the summit of the hill an extensive view is obtained on all sides.

To the west at a distance of about six miles the country becomes distinctly hilly, which nature it maintains in a North and South direction for many miles.

On the three other sides of Chandragutti, forest extends over a comparatively flat area, patches only being free from it where cultivation is carried on; these usually occupy the low ground where streams can be utilised.

The jungles which may be traversed for many miles without meeting with any exposure of rock are very largely composed of evergreens. The flatness is largely due to an extensive spread of laterite, the underlying rock being of a lithomargic nature.

In the South Western corner of the Shikarpur Taluk are two conspicuous parallel ranges of hills composed of Jaspery Hæmatite Quartzite, that are connected at their North Western end by a cross range three or four miles in length, standing practically at right angles to the general North Western strike of the ranges. Within these is a central equally prominent range of a Felsite rock.

Shikarpur Taluk.

A tributary of the Kumudvati river cuts across these hill ranges near the village of Ambaligola.

The whole area is forest clad, evergreen, teak and bamboo forming haunts for game of all sorts. Elephants were particularly in evidence at the time of my visit.

Immediately North of Anantapur runs a parallel range of hills which at a distance of about five miles North of the Kumsi-Anantapur road, turn abruptly to the West. Two and a half miles S. W. of Tagarti village a North Westerly trend is taken and the hills soon die out.

At their Southerly end, they cut across the Jaspersy Hæmatite Quartzite range just North of the high road, a fault between the two occurring $1\frac{1}{2}$ miles South of $\Delta 2,712$.

Except for the Jaspersy condition of the Hæmatite Quartzite in the one range no essential difference was noticed between them.

Within the area under report the rocks consist of:—

- (a) In the Sorab Taluk ... Banded Magnetite Quartzites.
 Hornblendic and Micaceous Quartz
 Porphyry.
 Garnetiferous Mica Schist.
 Crushed Quartz Porphyry or Tuff
 (Pseudo Grey-Wacke.)
 Lithomarge.
 Laterite.
 Quartz Syenite with dolerite Dykes.
 Quartz Reefs.
 Clay.
- (b) In the Shikarpur Taluk... Banded Jaspersy Hæmatite Quartzites.
 Manganiferous Hæmatite.
 Lithomarge.
 Laterite.
 Felsite.
 Trap.

Banded Magnetite Quartzites.

To the North and North East of Shiralkoppa are a few low ridges of hills that owe their existence to beds of Ferruginous Quartzite and lenticular masses of Hornblendic Quartz Porphyry passing into a Garnetiferous Mica Schist.

The outcrops of Ferruginous Quartzite are largely crumpled and dislocated, more particularly at the Southern end where their position has been affected by the strong ranges of Hæmatite Quartzite that sweep round from N. E. to E. N. E. a few miles North of Shikarpur.

The rock is banded, slightly magnetic, occasionally strongly so, brecciated, and in part jaspery.

Description.

Amongst the hills $1\frac{1}{2}$ miles N. E. of Hulginkoppa they possess a cleavage of N. 35° E. Four roughly parallel bands of outcrop can be traced. The beds of the two central bands number nearly a dozen, but in no one place are they all represented. In the Eastern and Western bands there are not more than two beds in each.

Taking the dips as a whole we find in the Northern half of the most Eastern band a dip of from 60° — 75° E. which is reversed to the South West in the Southern half, with an angle of 40° — 45° .

Dips.

In the two central bands the majority of dips are Westerly at angles varying from 55° — 75° .

The Westerly band starts at the South with an East and West strike and dip of 45° S. It then follows the bow shaped curve of the central band with a larger sweep, and near Kerehalli is found striking North and South, with a dip E. 55° . The central portion of this curve would pass near Tavanandi village, but as a matter of fact only laterite is to be seen here.

In the tract of country lying between Siralkoppa and Ulavi is another group of outcrops, representing about 10 beds of Ferruginous Quartzite, with dips suggesting a deep synclinal fold. At their Southern end their strike is N. W. but South of Andige a sharp turn to the N. W. is taken. The most Northerly bed of the group which runs roughly parallel with the high road between Siralkoppa and Sorab has been traced to within $\frac{1}{2}$ mile of the latter town, but no continuation could be found either to the South or West of Sorab except for a small outcrop about one furlong S. W. of the village of Tavarehalli.

The only other locality where any outcrop of these Magnetite Quartzites was observed lies about $5\frac{1}{2}$ miles to the N. N. W. of Anantapur where an anticlinal fold can be traced between the Southern spur of $\Delta 2,628$ and the Western spur $\Delta 2,544$. Here it is associated with the Garnetiferous Mica Schist, and the condition of the rock is much fresher than elsewhere, it containing many lenticular bands of fibrous grünerite.

A thin section of the rock shews a banded Magnetite Quartzite with fibrous prisms of grünerite, which, where the size permits, shew a fine lamella structure and an extinction angle of about 17° , sometimes largely altered into hydrated oxide of iron. The grünerite is chiefly confined to the siliceous bands though a few crystals are also to be found in the magnetite bands. The magnetite occurs in irregularly connected groups or strings of crystals, quartz occupying the interspaces. H₈/915. There is no clear evidence in the thin sections examined of the formation of magnetite by the oxidation of the iron silicate grünerite. The yellowish brown alteration product derived from them is of a later production than the black metallic crystals as it penetrates fractures in them and much of it is not improbably derived through hydration from them. H₈/917.

The above series of Ferruginous quartzites differ from those in the Shikarpur Taluk in the following points:—

- (a) They maintain an average North-Westerly strike.
- (b) They are invariably associated with a particular variety of quartz porphyry or garnetiferous mica schist and a Quartz Porphyry Tuff or Pseudo grey-wacke.
- (c) They are often magnetic.
- (d) They are non-manganiferous.

HORNBLENDIC AND MICACEOUS QUARTZ PORPHYRY AND GARNETIFEROUS MICA SCHIST.

These two rocks must be considered together as the latter is only a locally metamorphosed phase of the former.

They form a lenticular mass of about 7 miles in length and two in breadth amongst the beds of "pseudo grey-wacke" or Quartz Porphyry Tuff in the Sorab Taluk to the North of Shiralkoppa. Its Northern boundary could not be ascertained owing to cultivation. In the field they present the appearance of a dark mica schist

in which garnets may often be distinguished with the naked eye. The outer edges of the lenticular mass are highly brecciated, and mylonitization is seen in the micro section.

Macroscopic description.

This rock is identical with the banded mica schist extending from Mallebennur to Harihar, described in Records Volume IV, page 131.

The correlation of this type with the garnetiferous mica schist found $2\frac{1}{2}$ miles S. W. of Hanagere also with portions of the conglomerate bed 3 miles to the East, on the Western flanks of the Shankargudda Range, and of this series, with the garnetiferous micaceous granulites referred to as mica schist in Records Volume V, page 43, has been determined.

The peculiar bluish green skeletal crystals of Hornblende are common to both the granulites and Quartz Porphyry. The presence of cummingtonite in one phase of the granulitic porphyry suggests a close connection with the magnetite quartzite with which they are associated.

The microscope shews a considerable variation in the proportion of felspar, the quantity usually present is equal to that of the quartz, together forming a groundmass with biotite mica to the phenocrysts of skeletal or cellular crystals of bluish green hornblende and garnet which have enclosed in their growth portions of the groundmass.

Microscopic description.

The crystals of hornblende occasionally stand perpendicularly to the general foliation. Distorted, fragmentary remnants of porphyritic felspars and quartz are evidence of the pressure to which it has been subjected. The felspathic portion of the groundmass has sometimes recrystallized as granular epidote, while an occasional prism of Tourmaline may be seen.

QUARTZ PORPHYRY TUFF OR "PSEUDO GREY-WACKE."

This occurs extensively in the North-Eastern portion of the Sorab Taluk associated with beds of Magnetite Quartzite and Mica Schist and extend many miles in a North-Eastern direction across the Dharwar District as far as the Southern Mahratta Railway, beyond which they have not been followed. The westernmost point at which it was observed was about 5 furlongs S. S. E. of Kerehalli; and about 4 miles to the E. N. E. of Sagar it forms 2,314 and 2,170

striking W.N.W. with a dip of 35° — 45° N.N.E. Overlying it here is Laterite.

A few miles to the N. E. of Shiralkoppa the series is somewhat disturbed where it abuts against a bed of similar rock that conforms with and overlies the strong range of Haematite Quartzites that turn sharply from N. N. E. to East and West a few miles North of Shikarpur. From this point Eastward they may be presumed to extend across the intervening strip of the Dharwar District conformably with the Haematite Quartzite, when East of the Thungabhadra river they form two of the undermost beds of the Malebennur series referred to in the Department Records Volume IV, page 133.

Their association with a Ferruginous quartzite was observed in that region and is much more apparent in the Sorab Taluk.

The origin of the rock is still one of doubt. Portions may represent a crushed Quartz Porphyry from which cannot be separated others, presenting the appearance of an accumulation of subangular fragments of several types of an intermediate felspathic lava.

Microscopic description. Chlorite and magnetite are present in some instances, and Hornblende in small fibrous prisms and acicular needles dispersed throughout in others. These show the rock to have largely recrystallized as many needles intrude the angular fragments of quartz and felspar. The presence of the Hornblende can only be seen in thin sections.

These Hornblendic bands are observed where the series is in proximity to a ferruginous quartzite, but it cannot at present be stated that the one has had any direct influence on the other.

The rock has been largely quarried in several localities as it may be obtained in slabs of fair size. It was formerly used largely in the construction of temples and of recent years it has been utilized for mile and furlong stones.

The following are localities where it has been observed quarried:—

Two furlongs S. S. W. of Muthalli.

One furlong E. of 2369.

Five furlongs S. E. of Ginevala (Ninivala).

Three furlongs S.—3 furlongs S. S. W. of 2171.

One furlong S. of 4th milestone—Sagar-Sorab road.

Two furlongs E. of 2314.

Five furlongs E. 30° S. of Nadkalshi.

Western side of 2244.

Lithomarge.

By Lithomarge I mean a usually exceedingly soft, finely banded, delicately tinted, powdery rock found in various parts of the Sorab and Sagar Taluks.

Definition. It is closely associated with Laterite, often found underlying and passing into it.

There seems little doubt that it is the altered condition of a rock in situ. That rock appears to have been essentially felspathic and may be compared with a banded rock such as a Felsite or Rhyolite.

It is often found highly brecciated and cemented together by a red brick-like substance. H₈/872. In this binding material are yellowish white fragments too decomposed for identification, and a few minute grains of vitreous quartz. It contains numerous small cavities which are filled with botryoidal Haematite. On the weathered surface it is observed that the fragments of lithomarge are most easily removed their angular forms being retained by the cementing Haematite, the fine lamination in the fragments standing out like coral. On the summit of 2520, a small hill lying about 4 miles North of Bellandur, lime takes the place of the brick-like Haematite cement to the iron impregnated, brecciated, fragments of Lithomarge.

On weathering this calcareous cement is dissolved causing cavities which give the rock a lateritic appearance. Occasionally a silicified condition of the Lithomarge may be observed, but this is unusual.

The locality that afforded the most favourable examination of this form lies about 2 furlongs S. E. of the small village of Uddanur, where the transition from a pale sea-green finely banded, cherty

rock, traversed by veins of flesh coloured chalcydonic silica, into the banded ochery Lithomargic form may be followed.

The original white colour is but rarely seen, two occurrences only of it being noticed, the one on the summit of the small hill lying one mile S. E. of 2783 and the other, one furlong E. of 2537. A yellowish brown usually stains the whole, the colouration proceeding laterally from cracks that have afforded a passage to iron charged solutions, in some cases; and in others it is due to the uniform decomposition of Hornblende Biotite or Pyrites. The beds of an Indian red colour may represent originally garnetiferous zones.

The extension of the Lithomarge practically coincides with that of the Laterite, the most easterly points at which it was observed being $1\frac{1}{2}$ furlongs S. E. of the village of Hunavalli where it is almost in contact with the "Pseudo grey-wacke" and at the western end of the tank bund $1\frac{3}{4}$ mile North of Andige village, here in contact with and overlying a bed of the banded magnetite quartzite with a dip of 40° South. The range of hills immediately

Occurrences.

North of Anantapur is largely composed of it often in a highly brecciated form, $H_8/902$, cemented by Haematitic matter and forming Laterite.

It was also observed in three sections across the range to the East of Kannur underlying the Haematite Quartzite. The first locality is the pass between 2535 and the hill to the S. S. E.: the second, $2\frac{1}{2}$ furlongs S. S. E. of 2531, at the South Eastern end of the breached tank bund (not shown on the Topo Map) and the third in the cutting where the high road from Kumsi to Anantapur crosses the ridge. In each place it was impregnated with manganese; in the last mentioned locality the manganese took a stalactitic form enclosed in the lithomarge.

PETROLOGICAL DESCRIPTION OF -SILICIFIED LITHOMARGE.

By the examination of several thin sections of the silicified portions of the Lithomarge and their comparison with certain bands that go to form the Haematite Quartzite, the conclusion that they are of the same nature has been arrived at.

With such a silicified rock it is exceedingly difficult to follow the alterations that have taken place and to describe them clearly is more so. I shall therefore content myself for the present, with describing a few Micro Sections.

H₈/1044.—The rock is traversed by a number of threadlets of chalcydonic Silica which have had a permeating effect throughout, so that the rock which was probably originally felspathic to a very large extent, is now chiefly silica. The alumina in the original feldspar is represented as Kaolin forming a dust-like decomposition product and as bundles or radiating groups of micaceous microlites.

H₈/1046.—This is particularly interesting as it reveals three periods of formation of the chalcydonic silica.

The first is represented by a vein composed of interlocking plates grown inwards from the opposite sides. These are not entirely free from the feathery microlites which densely cover the section, but also contain a few comparatively large prisms of Rutile. This vein lies roughly parallel to the slight schistosity of the rock. Cutting across this at right angles is another vein of slightly different composition and structure. In ordinary light the sides of the vein are colourless while the centre is of a light umber in transmitted light and opaque white by reflected. Its polarization colours are similar to those prevailing throughout the section, *viz.*, yellows and greys of a low order. The structure is fibrous and divided into segments each giving their own limit to the undulatory extinction. The fibres stand normal to the walls meeting along a central line. Certain portions of this vein are intersected by what appear as irregular cracks which are again filled with a colourless silica, apparently an injection of that by which the mass of the rock is silicified. As silicification proceeds we have the concentration of the

feathery yellowish transparent microlitic matter into definite areas, in a more compact form. Sometimes it is finely disseminated in the later silica that fills the druses in the chalcydonic silica, produced by the disintegration of certain crystals.

Patches of disintegrated Rutile occur here and there, and also a few porphyritic crystals of the same mineral with apatite and sphene, passing into leucoxene.

H₈/879.—The original rock was a granulite composed entirely of felspar. It is traversed by irregular intrusions of silica and silicification has proceeded from these throughout the adjoining originally feldspathic rock, which is now marked by a net work of colourless to opaque yellowish acicular microlites representing Kaolin. A bunch of porphyritic crystals similarly altered is of interest.

Small quantities of a black non-metallic dust are concentrated along certain lines. A similar alteration on a larger scale may be seen in Micro Section H₈/711 taken from a felsite dyke which has been intruded by silica. The description of other sections will be made when dealing with the Banded Haematite-Quartzites, as bands of such as these go to form part of that series.

ALTERATION OF LITHOMARGE INTO LATERITE.

The simple alteration of Lithomarge into Laterite was noticed in an excavation about 50 yards South-East of the Eastern end of the Keladi tank bund (4 miles N. N. W. of Sagar).

Overlying the lithomarge for a depth of 6-7 feet is a loose laterite agglomerate containing angular fragments of Haematite and a few of quartz.

The first change in the alteration is the deposition of lime along planes of separation, which may be produced by shrinkage. The centre of these cracks is often left hollow. They widen in places into pockets which contain large quantities of lime, contrasting sharply in colour with the iron stained brick red portions. The

colouration may be produced from the decomposition of the chlorite and magnetite present in the "Pseudo grey-wacke" or the Hornblende and Biotite present in the Hornblendic Quartz porphyry or mica schist which underlie the Lithomarge. Another rock from which a portion of the Lithomarge may have been derived or at all events from which it has obtained much of its colouring is the magnetite quartzite.

Veins of blue quartz have often been observed traversing the
Cut by quartz veins. Lithomarge.

Lithomarge as a Pigment.

The extreme freedom of this Lithomarge from any gritty matter and the variety of shades of colour in which it occurs should make it of some value in the market as a pigment.

The commonest colour is yellow of different shades, but salmon, pink, brick red, Indian red, grey and white are found.

Another use to which this may be put is as a fire proof brick.

Laterite.

Laterite is practically confined to the western half of Sorab
Distribution. Taluk. The hills of Ferruginous quartzite that sweep round in a bow like curve in the vicinity of Tattur form the Eastern boundary to the lateritic area. Although it extends over a very large area it is only occasionally exposed owing to the extensive tracts of ever green forest.

The shallow valleys, in which the cultivation of rice is carried on, are often bounded by a sudden drop of 10 feet or so, from a fairly horizontal spread of Laterite. A good exposure occurs along the eastern escarpment of the rising ground around the village of Hanaji (1½ mile S. E. of Jade). It is for the most part extremely pebbly, most of which are of a vitreous friable quartz, seemingly waterworn. The brittleness of the quartz is such as to suggest the sudden contact of a cold with a hot body.

Haematite passing into laterite forms the hills 2—3 miles East of Siddapur, which are excluded from Mysore owing to a loop in the boundary. This small group is of interest as giving clearer indication of the nature of the rocks than can be expected from the less

hilly country adjacent in Mysore. The strike of the rock could only be seen in one place, *viz.*, $\frac{1}{2}$ furlong S. W. of the summit of 2241 where it appeared to be N. and S. dip 30° E. The laterite here is very free from quartz, no pebbles being present and only a few small angular fragments here and there.

Overlying this on the hill $3\frac{1}{2}$ furlongs S. E. of 2241 are traces of the brick coloured lithomarge which is again visible underlying another bed of laterite, as seen in a vertical section on the North side of the small tank at Silige where it is finely banded and extremely soft. The Laterite around Ulavi H₈/751, 762, is of the nodular, concretionary or pisolitic variety with numerous fragments of quartz, which would be formed from the disintegration of the three rocks predominating over this area, *viz.*, Lithomarge, the magnetite quartzite, and "Pseudo grey-wacke." This variety is what I understand as "low level" Laterite.

Two furlongs West of 2376 ($3\frac{1}{2}$ miles South of Tagarti) is an outcrop of Laterite H₈/895 which I presume to be what is usually described as "high level" Laterite.

This contains no brecciated fragments of Lithomarge or any other rock but consists entirely of the brick like matter that usually forms the binding material to the brecciated Lithomarge in which condition the two form another variety.

It has been impregnated with a mangiferous solution which is deposited in films. The commencement of deposition of limonite in concretionary forms causing cavities with mammillary surfaces is apparent.

As I regard this form of Laterite to be a ferruginous mud lava, this first alteration, *viz.*, the deposition of limonite, may be due to the solvent action of the steam it contained, the cavities being in the first instance blowholes which have been subsequently enlarged and connected by dissolution and redeposition of its iron content.

Lateritic Gravel.

The two small hillocks 1920 and 1826 lying to the North of Anavatti are composed of lateritic gravel with a superficial covering of pebbles of white quartz, not unlike a shingle bed. The latter

hillock is worked for road metal. A good lateritic gravel is also exposed in some pits below a surface covering of 18" of whitish soil, along the side of the road recently constructed between Anavatti and Tavanandi, within a mile of Anavatti.

Also by the road side between the 4th and 5th furlongs of the 6th mile on the Sagar-Sorab road. Here the upper 4—5 feet crumbles easily, but below it takes a much firmer form. The cavities it contains are irregular in shape, and are sometimes seen to contain the lateritic granules that form the upper 4—5 feet. These granules appear to be formed by a concentric deposition of ferric Hydrate on solid particles as centres in the original rock. Fragments of white quartz are not infrequent in the lower portion. On the North side of Keladipur a lateritic gravel H₈/790 A is excavated and used as a pigment.

A secondary, recent laterite H₈/1093 lies at the South-Western foot of the hill slope, $\frac{1}{2}$ mile North of the 197th milestone Kumsi-Anantapur road. Here fragments of the overlying sandy ferruginous rock are cemented together by brick like ferruginous matter.

Recent Laterite.

The lateritic spread H₈/930 around the village of Tagarti is of such an altered nature that its production can only be surmised. No brecciated fragments of any original rock are found in it.

Formation of Laterite.

The transition of Lithomarge into Laterite was observed in a number of localities; one such lies at the side of the foot path leading into the village of Otur (3 miles N. N. E. of Sorab) about 20 yards South of the Temple shed. The alteration here begins along cracks, cleavage or fractures when a leeching out process commences.

In the lithomarge, first appear cavities tubular in section filled with a core of grey kaolin shading off into an ochry yellow or brick red. With the gradual spread of this alteration along the planes of separation we get the alternation of the dark brick red more ferruginous portions with the purer dirty white clay and the rock at the same time becomes harder. The laterite strikes down in finger like projections into the soft Lithomarge. Going further

back and trying to find the origin of the Lithomarge here, we have faint indications of its being the alteration of a fine grained Hornblendic felspar rock.

Quartz Syenite.

The only exposure of this rock as already stated lies on the extreme Western side of the Sorab Taluk, where it covers an area of about 16 square miles.

The most important hill of the group is Chandragutti which rises to a height of 2794 feet or 940 feet from its base.

The rock possesses two principal directions of cleavage, *viz.*, W. 10-15° N. and N. E., it is of a medium grain and light grey colour and very similar to that found near Kodur forming portions of Ammanagudda some 36 miles S. 30° E.

It contains tabular plates of felspar with albite and pericline twinning undergoing alteration into epidote and sericite; other tabular crystals with a pseudo micrographic structure are undergoing recrystallization into porphyritic perthitic plates and scapolite. The ferro-magnesian mineral is biotite, while epidote and sphene occur as accessories. Quartz intrudes this otherwise quartzless rock in veinlets.

Micro description.

Lying within this Quartz Syenite area in a strong vein of dykelike form, is a rock which was traced from 1 furlong South of the 14th mile on the high road between Sirsi and Siddapur villages lying just beyond the Mysore Boundary in the North Canara District in an Easterly direction for a distance of 5 miles.

At both extremities it has the appearance of a decomposed pegmatite, highly brecciated and at its Eastern end it appears to pass off into the Quartz Syenite.

At intermediate points it becomes felsitic and in places it is seen as a porous quartz rock in which secondary silicification and impregnation by Haematite has taken place, the resulting rock being a brecciated Haematite Quartzite.

The drusiness has been produced by the removal of fragmented felspars the cavities thus produced permitting the crystallization of

prismatic crystals of quartz and stalactites of Haematite. The dip varies from perpendicular to 70° E. or W.

From the examination of a few micro sections it is probable that the original rock was porphyry that had intruded the quartz syenite as a dyke, brecciation and the intrusion of a syenite magma followed, to be again subjected to further brecciation, removal of the felspar and intrusion of veinlets of silica and Haematite. In Micro section H₈/710 which represents the rock in its crushed and iron impregnated condition, we appear to have the replacement of the entire felspathic constituents in a quartz porphyry by haematite, which thus presents the appearance of fragments of quartz crystals, a few of which still retain portions of their idiomorphic forms, lying in a matrix of Haematite. A somewhat similar process of intrusion, substitution and alteration was observed in three other localities, *viz.*, one furlong South of 2286 or $2\frac{1}{2}$ miles North-East of Tattur where were some fragments (H₈/626) of rock whose association with the garnetiferous mica schist could not be explained; again $2\frac{1}{2}$ miles E. N. E. of the last locality where a large reef of quartz and epidote, in parts brecciated and ferruginous, forms the back bone to the small hill 2164, and thirdly on the summit of Karadibetta where a felsite is intruded by a regular net work of veinlets of silica.

Quartz Reefs.

About $2\frac{1}{2}$ miles East 5° North of Hulginkoppa are a few quartz reefs with an apparent E. and W. strike lying in the "Pseudo grey-wacke."

The quartz is of an opaque milky blue colour somewhat "mouse-eaten" indicating the decomposition of tourmaline or chalybite. Two or three small pits are found along the outcrop which may represent prospecting work at some distant time and may be worth attention.

Similar quartz reefs to the above are again found 3 furlongs E. S. E. of Sadapur.

Another small reef occurs on the rising ground 3 furlongs South of 2047 a small hill surmounted by some earth works, probably constructed for military practice, lying about $\frac{3}{4}$ mile S. S. E. of the village of Chik Kerur.

The reef runs parallel with the country rock (Pseudo grey-wacke) and has been pitted in places, whether for road metal or prospecting, one cannot say.

Hill 2164 lying $3\frac{3}{4}$ miles due West of Chik Kerur is composed of a strong reef of epidote and quartz, bearing S. 10° E.

At the Southern base of the hill it takes a slightly more Easterly trend and becomes lost under soil. A small outcrop of quartz, $1\frac{1}{2}$ miles S. of this point probably represents a continuation of this reef.

Portions of another large quartz outcrop are to be seen on the S. and N. side of the small hill 2006 lying $\frac{1}{2}$ mile East of Basur and again on the hill to the North 2103. The Kerehalli tank bund is probably constructed on this reef as it again shows at the Northern end of the bund. The Western side of 2006 has an artificial, pitted appearance which may be due to the earth excavated for the small fort that must once have crowned the hill.

The small hill lying on the N. W. side of Kerehalli bears the name locally of Honnegudda from the fact, according to local tradition, of a large quantity of gold treasure having been found on it by the great grandfather of the present patel of Kerehalli. The spot from which the treasure was removed is undoubted as on the top of the Northern spur numbers of ancient bricks $6'' \times 6'' \times 3''$ in size lie scattered about and a few of which may be seen in their original place undisturbed. Similar bricks were noticed at the Northern end of the crest of 2200, a low hill $4\frac{1}{2}$ miles South of Kerehalli.

Numerous other reefs were observed cutting the large felsite bed referred to later, especially to the South and South-East of Karadibetta for the locations of which reference may be made to the accompanying map.

Dykes.

Dykes of four varieties were noted:—

- (a) A hornblendic Spheue bearing granulite cutting the quartz syenite, especially at the Southern base of Chandragutti with an E. N. E. strike.

- (b) An olivine enstatite dolerite intruding the Garnetiferous Mica schist near Hire Magadi.
- (c) A decomposed augite dolerite. The slightly titaniferous augite this contains is partly uralitized adding at the same time Titanite to that already present which is passing into Leucoxine. The feldspars are largely sasuritised and granular epidote is being formed.

These cut the Pseudo grey-wacke and one was found cutting the felsite $1\frac{3}{4}$ miles S. S. E. of Karadibetta.

- (d) The fourth variety is similar to the coarser grained portions of the Hornblendic Lava described in the report of the previous Field Season Records Volume VII.

It was located in four places which if connected up would give it a strike of N. W. Its position 1 mile S. of 2651 Doddabetta may indicate a line of fault which would account for the sudden cessation of the Ferruginous beds forming Doddabetta.

The second point where it was observed is in the saddle $2\frac{1}{2}$ furlongs S. 15° —E. of 2416 where it may be responsible for the disturbance of the beds of Haematite quartzite in this quarter.

The third and fourth localities where it is exposed are 3 furlongs W. S. W. of 2438 and 7 furlongs East of 2783.

Clay.

In the shallow valleys characteristic of the Malnad country, underlying many of the flat fields under paddy cultivation is to be found a stratum of good plastic clay worked here and there by the local potters. The depth below the cultivated surface at which it is found varies in different localities; about a furlong West of Totlagondanhalli (4 miles North of Sorab) it occurs at a depth of 5—6 feet, and the thickness of the bed is from 1—2 feet. Below this nodular Kankar exists which is unworked.

Another locality from which a sample was brought is $\frac{1}{2}$ mile West of Kadsur H₈/824-825.

Passing now to the rocks in the Shikarpur Taluk and unrepresented in the Sorab we have first the

BANDED JASPERY HÆMATITE QUARTZITES.

This rock forms the backbone of the hills that run in two parallel ranges about $4\frac{1}{2}$ miles apart on either side of the Ambaligola felsites.

The direction of the ranges is approximately N. W. At the North-Western end the two ranges become joined together by a cross range. The beds forming this portion are sharply folded and at several points along the S. W. range we have evidence of sharp folds with their axes parallel with the ridge. The dips are high usually varying from 75° N. E. to vertical. The N. E. range is composed of two well defined beds dipping at a fairly uniform angle of 55° N. E.

To the East of Karadibetta these are somewhat disturbed and about $1\frac{1}{2}$ miles S. E. of that hill they are lost in the low lying ground, but may again be represented by beds forming 2,414 about 2 miles North 15° E. of Choradi.

The bands composing the rock vary from colourless quartz to dark grey and red in the Jaspery condition. The latter is particularly noticeable near the villages of Jambani and Kaniya. Many of the bands are different shades of grey and strongly resemble a siliceous felsite or rhyolite.

In the micro-sections we have evidence of many of the grey bands being feldspathic and originally this series must have been a feldspathic rock of the nature of a felsite or granulite. Subsequent silicification has for the most part rendered the original nature of the rock unrecognisable.

This silicification is due to the intrusion of bands of quartz which have in many places been largely impregnated with Hæmatite introduced along perpendicular joints and from these the solution has worked its way horizontally. When this takes place we usually have a brecciated rock, portions of the siliceous bands present the appearance of having been forced apart by the growth of the infiltration H₂/845. By further brecciation we get small angular

fragments of quartz cemented by or lying in a matrix of Hæmatite. The following are some micro-sections illustrating this phase.

H₈/845.—Drusy bands of chalcedonic silica highly charged with dusty impurities alternate with finer more compact ones. The druses appear to be formed by the disintegration of magnetite crystals which go to partially form some of the fine black dust, a recrystallization in the druse taking place, of acicular Hæmatite that may sometimes easily be mistaken for rutile needles, especially in micro-section H₂/847. These become more massive till the entire cavity is filled and a band of granular Hæmatite is formed the granules being either separate or joined together in a moss-like mass. The crystallization of the Hæmatite spreads in the quartz in a honey-comb-like structure of rods. H₈/1012.

H₈/846.—Exhibits a crystallization of micro-crystalline silica, with faint banding, due to the varying concentrations of an impalpable dust. A vein of chalcedonic silica cuts the rock at right angles to the banding. The fissure is edged on both sides with globules of Hæmatite.

The high power lens shews the silica throughout to be secondary with many druses and colourless grain of highly refracting mineral.

H₈/1062.—Is a banded Hæmatite Quartzite. The ferruginous matter in the form of Hæmatite is slightly concentrated into bands, the greater part of it in the form of microscopic granules or globules which have acted as a partial cement to the small fragments of quartz, into which the whole rock has been crushed. Special lines of fracture are marked by a curious development in appearance similar to crushed ice which may represent moisture.

Subsequently to this a recrystallization throughout of the silica has taken place by which cavities have

been able to partially develop idiomorphically. These cavities are filled with a yellowish brown semi granular mineral edged by Hæmatite; scattered here and there are crystals of Brookite. The high power reveals two colourless minerals with apparently low double refraction which is however partially marked by the underlying silica.

Their refractive index is high, their chief difference from one another being the number of small irregular facets on the one and the smooth rounded outline of the other.

Banding.

The dark colouration of many of the bands does not appear to be due to any ferruginous mineral, but to a non-metallic dust which gives no colouration to a borax bead. This is found in what I consider to represent a silicified felsite or rhyolite.

A very finely banded and contorted illustration of this rock is seen on the Western spur of 2,238 about four miles West of Shikarpur and a brecciated condition of it both here and $\frac{1}{2}$ mile E. N. E. of Honbandikere. Veins and angular fragments of Kaolin are found in the dark grey felsite like bands. Not only has the finest grained felsitic phase of the intermediate lava been silicified and rendered ferruginous, thus forming Hæmatite Quartzite, but also other phases such as the granulites and quartz porphyries whether in the form of dykes or interbedded sheets.

Intrusive veinlets or bands of silica occur invariably and appear to be one of the necessary actions to its formation.

Iron.

The smelting of iron formed one of the most important industries in by-gone times. In the Sorab Taluk the ore was partly obtained from the beds of Magnetite Quartzite, the process of crushing and separation by washing being necessarily employed and partly from Hæmatite.

Beds of the former were worked at the following localities.

(a) Half a mile South of Shigga.

- (b) at various points along the E. and W. outcrop occurring $1\frac{3}{4}$ mile, North of Andige.
- (c) Three-fourth mile South and 1 mile S. W. of Andige.
- (d) $\Delta 2,180$ —1 mile S. W. of Tallur.
- (e) $\Delta 2,172$ —3 furlongs S. W. of Hunasavalli.

In the Hæmatite extractions were made:—

- (a) Three-fourth mile North of Nallur where there are a number of pits on the Southern side of the hill.
- (b) About 3 furlongs W. N. W. of Yedgoppa, now known as Channapatna, the ground has been largely disturbed; pits varying to 15 feet in depth cover the ground which is of the nature of a lateritic gravel.
- (c) About 1 to $1\frac{1}{2}$ furlongs West of 2,058 is another locality. The method of open pits is the same as that employed one mile to the N. W.

The village of Channapatna lying midway between the two, must have been important at one time as a smelting centre. The work there is now carried on with imported metal.

- (d) Two and a quarter miles South of Chandragutti village about 3 furlongs from the village of Toravagondankoppa.
- (e) From the pass one furlong S. E. of 2,349. South-Eastward to the summit of the next small hill are a few small pits worked on an anticlinal fold in the Hæmatite Quartzite.
- (f) The iron ore that was smelted at Kuni Hosur some 30 years ago was obtained from the small hill 3 furlongs S. S. E. of that village. Slag No. H₈/1052.
- (g) Extensive old workings for iron are found to the N. N. W. of Uddanur village on the hill side some 6—7 furlongs N. E. of 2,531.
- (h) A few small pits 2 furlongs West of 2,086.
- (j) A large pit 20—25 feet in depth and 50—60 yards across lies at the Northern foot of the small hill South of Hoskoppa.
- (k) On the Eastern brow of the small hill 3 furlongs N. E. of Hosur or 1 mile N. N. E. of Choradi in the brecciated Hæmatite Quartzite.

- (D) On the summit of the hill 11 furlongs S. E. of $\Delta 2,651$ (Doddabetta) in the sides of a large pit representing an old working are traces of manganese.

This worked bed overlies one of beautifully banded Hæmatite Quartzite which passes into a fairly pure bed of Hæmatite ($H_8/112$) about 10 feet in thickness.

This lies unconformably on a bed of the brecciated Hæmatite Quartzite in which again we find numerous pits where iron has been worked on the S. S. W. side of the hill.

Smelting has been carried on at the following villages:—

- (a) The present village of Honbandikere lies about $1\frac{1}{2}$ furlongs S. E. of that shewn on the Topo Map. A few trees mark the site of the former village which no longer exists.

Entering the jungle from the North side of the present village and going in an E. N. E. direction we come up on numerous mounds of slag. It is not certain what the ore smelted was, whether iron or copper or from where it was obtained.

- (b) On the North side of the most northern section of Jambani village, in the midst of the evergreen jungle, are to be found ruins of what must at one time have been an important industrial village.

To the north of these ruins are a large number of dumps of slag which differ slightly in appearance from the ordinary iron slag, and, as there is a report handed down for a number of years that copper used to be smelted there, the slag, may represent that industry.

The spot from which the ore was probably extracted is not more than $\frac{1}{2}$ mile distant at the base of the western slope of 2,649. About 100 feet below the crest of the hill is a line of pits extending from due West of the highest point of the hill, to within a few yards of the saddle to the South.

- (c) About 3 furlongs S. S. E. of Ambaligola may be found in the jungle the ruins of a village the history of which is unknown. Near it smelting was at one time carried on, but this may have been done by the inhabitants of Hadarvalli which village also no longer exists. Slag No. $H_8/959$.

- (d) Smelting at one time was the industry of Marahunasi and Vedivattikoppa, two non-existent villages marked by a \times about 1 mile W. S. W. of Ambaligola. Pits are found here in the felsite near the small temple.
- (e) Another deserted village is Bettadharaka that formerly carried on iron smelting.
- (f) Perhaps one of the most important later villages where smelting was done is Madarvalli ($3\frac{3}{4}$ miles E. 15° —S. of Ambaligola) where work was stopped about 50 years ago. Large mounds of slag are found near the temple and one furlong S. W. of it.

The iron ore was obtained from the N. E. slope of the hill, $1\frac{1}{4}$ miles S. W. of the village, where at least a couple of hundred small pits mark the spot. Slag No. H₈/975.

- (g) Smelting was also largely carried on on both sides of the tank, $2\frac{1}{2}$ —3 furlongs W. N. W. of 2,328 ($2\frac{1}{2}$ miles S. W. of Tagarti) Slag No. H₈/1065.

Old workings in which the mineral sought for is unknown:—

- (a) A few small perpendicular pits are found along the Eastern side of a strong band, some 20 feet wide, of clay iron stone occurring about 5 furlongs S. S. W. of 2,662 and also 6 furlongs North 30° West of 2,662 a hill $2\frac{1}{4}$ miles S. E. of Hireharake.
- (b) One mile west of 2,662 is a \times shewn on the Topo Map which marks the site of a ruined village and also several pits which were worked formerly in all probability for iron.
- (c) About 11 furlongs N. N. E. of Choradi are hundreds of small pits running in a N. and S. direction, no outcrop of any rock is visible just here to suggest what it was that was worked for. Immediately to their East is a large moat running N. and S. which encloses over $\frac{1}{4}$ square mile of ground but within it no trace of any former habitation is to be found. Some years ago I remember to have been told that copper was to be found somewhere in this direction.

- (d) The ruined village of Bellandur covers quite a large area. It must have flourished about the same time as those near Jambani and Honbandikere. It is now nothing but an uneven surface overgrown with Bamboo, the outer moat alone being still fairly defined.

The village was built on laterite as was also that near Jambani, as seen in the wells which are numerous on the South side and larger than is usual.

It occurred to me that some of these might represent shafts for ore lying at the base of the laterite.

A large number of pits are to be seen on the West and N. N. W. side of the old village as far as the summit of the small hill where the rock appeared to be somewhat of the nature of the clay iron stone.

Is it possible that the name Bellandur "village of sugar-cane," is a corruption of Bellindur "village of silver"?

- (e) In the pass between 2,535 and the hill S. S. E. or $\frac{3}{4}$ mile E. N. E. of Kannur is an extraordinary artificial cutting across the strike of the beds of Hæmatite Quartzite. The deepest portion of the cutting is some 30 feet with a width of 4—5 feet.

At the S. W. end it broadens and a peculiar dark grey unctuous form of manganese occurring between the folds of the Hæmatite Quartzite has been excavated from the bank on either side.

It would be interesting to know for what purpose this was used as it was evidently worked many years ago.

The direction of the cutting changes from N. E. to N. N. E. in the centre of the saddle, where the depth is about 20 feet. On the S. E. side is a small shaft about 4' x 4' with a visible depth of not more than 4—5 feet. A little timbering still remains at the mouth. This is situated in the centre of a sharp bit of folding. I can only imagine an auriferous quartz reef to have been followed.

A somewhat similar cutting but on a much smaller scale occurs in the pass 3 furlongs S. E. of 2,531 or 7 furlongs E. S. E. of Kannur. This cuts a blue quartz reef that runs parallel with the

Hæmatite Quartzite. S. and N. 30° —W. on the Southern side it becomes very mixed with the Hæmatite Quartzite. Within 10 yards of the trench a curious opening is found in it, about 2 feet wide running North. This trench may however only be the overflow of the tank which is here constructed. A third small old working was observed on this same range where it is cut by a tributary of the Kumadvati river near Hireharaka. This is found on S. E. side of the cart-track from Gavaja to Ambaligola.

This excavation is made between folds of the Hæmatite Quartzite and is large enough to permit a person to wriggle in with difficulty for a distance of about 20 feet.

A local tradition gave the passage as extending to Choradi, nobody having dared enter it for years, the most done to prove that statement being the putting of a fowl in at this end which was seen to emerge at the other. The entrance is marked by a small, originally domed, chamber, built in the Mohammedan style.

On the South side of the present village of Honbandikere we have the ruins of an ancient mining village now in a state of pits and mounds some of which it is just possible may be old workings. Undoubted old workings however occur, in a soft micaceous rock probably an altered and weathered condition of felsite crowded with decomposed crystals of iron carbonate, on the N. E. side of the small tank that lies $\frac{1}{2}$ mile N. E. of 2,649. It is possible that these were for gold and hence the name of the village.

Manganese.

Manganese is found impregnating the beds of Lithomarge already referred to, but nowhere were the surface indications promising from a commercial point of view.

The following localities were discovered :—

- (a) Half mile W. 30° —N. of 2,520 specimen H₈/879, 948, 949, 950.
- (b) Three furlongs S. S. W. of Channapur specimen H₈/792.
- (c) Three furlongs East of Bettadharaka H₈/962, 963.

These all lie on the inner side of the Hæmatite Quartzite range which, as already stated, it also underlies.

To the South of Tagarti we find it on the summit of 2,421 in two narrow beds H₈/891 on either side of one of Hæmatite Quartzite. The strike is N. W., but there appears to be a sharp fold in the beds at this point which would render looking for it S. E. useless. It is much mixed with sandy quartz, but the friable nature of the rock might make their separation possible. Slight manganiferous impregnation in the Lithomorge was also observed on the summit of 2,628 specimen H₈/911.

A bed of manganiferous clay iron-stone extends in a N. W. direction to the West of the villages of Hoskoppa, Taralgere, Narsipur and Gavaja. Specimen H₈/1064 taken from 6 furlongs S. 10° E. of Taralgere.

The clay iron-stone is a banded, contorted and brecciated rock, formerly of the nature of mica schist or altered quartz porphyry, now highly impregnated with iron.

Similar rock to this, also manganiferous, is found to the S. E. on the North-Eastern brow of the small hill $\frac{1}{2}$ mile E. N. E. of Kambadur.

A garnetiferous schist underlies it here and overlying is a strong bed of brecciated friable ferruginous quartz from which most of the angular brecciated fragments have been removed, the Hæmatitic banding material only remaining, many of the cavities also being partially filled with a moss-like crystallization of stalactitic Hæmatite.

The history of this rock has been attempted in this report when dealing with the quartz syenite area, the only difference being that there it was probably a felsite dyke that underwent the changes and here it is more probably an interbedded sheet of a rhyolite or quartz porphyry.

QUARTZ AND FELSITE PORPHYRY.

A large body of this rock occupies the central position enclosed by the ridges of Jaspersy Hæmatite Quartzite above referred to.

It possesses an average width of two miles; the broadest portion lies immediately North of the Kumsi-Anantapur road, where it covers $3\frac{1}{2}$ miles from West to East; to the South of the road it

tapers off suddenly apparently dying out just before the Ayanur-Kodur road is reached. This is probably accounted for by the existence of a fault that passes approximately North and South at the 190 milestone. The total length of the bed, or rather series of beds, is 17 miles.

Fault.

In the North-western portion the strike has an average of W. 30°—N. with low dips of 25—30° N. E. while to the South of the Kumudvati tributary which cuts across the series the strike becomes S. S. E. with a slight increase in the angles of dip the average being about 40°. The North-western boundary is marked by a large stream running parallel with the strike of the felsite.

Strike and Dip.

In three localities, *viz.*, $1\frac{1}{4}$ mile North 10° East of Bellandur, 6 furlongs N. N. E. of 2,674 and $\frac{1}{2}$ mile N. W. of Karadibetta, Δ 2,693, the Felsite becomes highly charged with Pyrites, which through decomposition gives the rock a yellowish brown colouration. In the first mentioned locality an unusual phase of the felsite is seen near the top of the Western slope of the hill.

Pyrites.

Here the yellowish groundmass is blotched with amygdularlike bodies of quartz and felspar, the former occupying the centre.

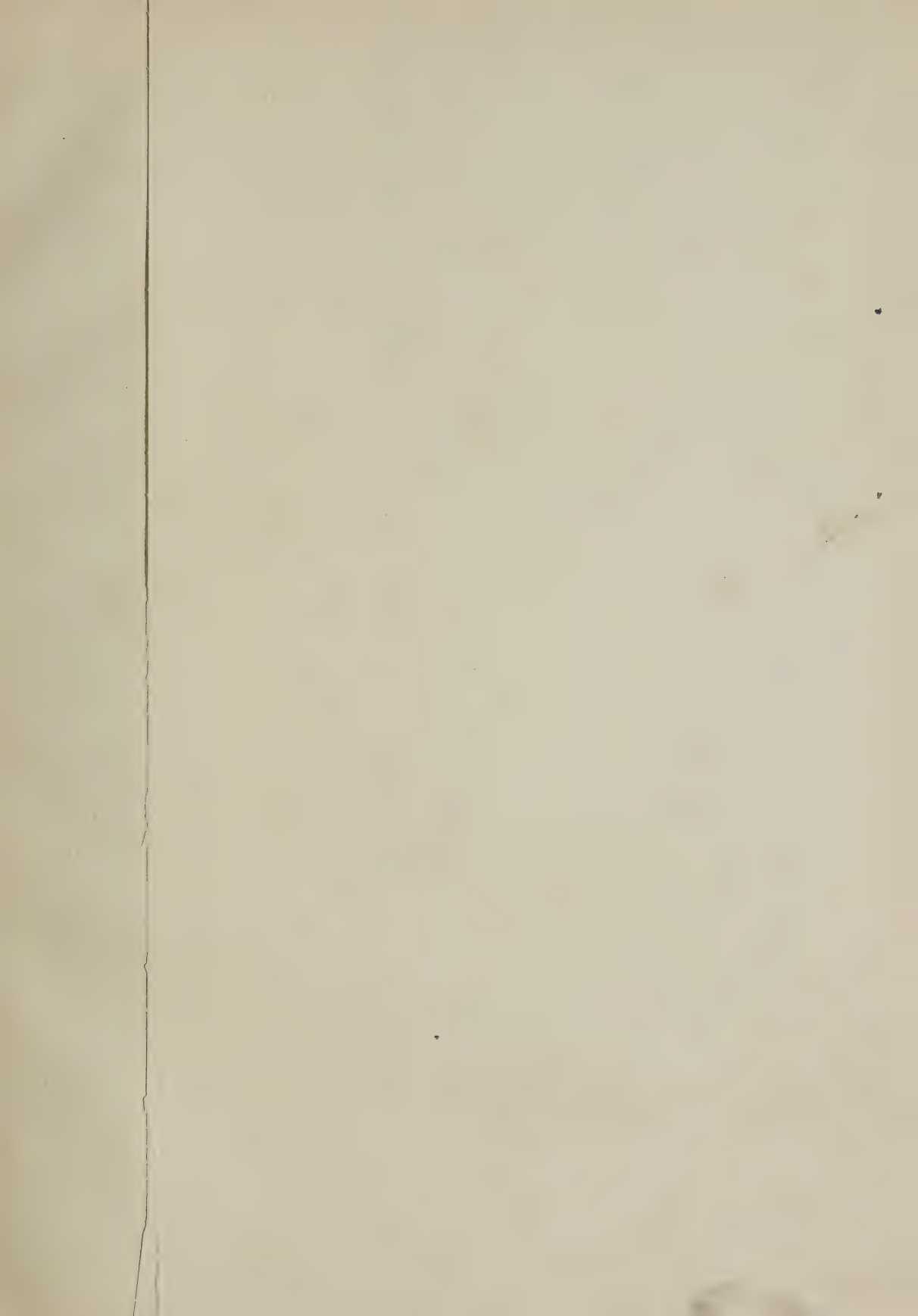
Under the microscope the rock is seen to consist of pseudo-spherulitic growths of felspar arranged perpendicularly to planes of resistance caused by the intrusion of siliceous matter. It is not clear whether this was also feldspathic, it is clearly so now, but this may be due to partial absorption. The augen or pseudo-amygdules are formed by the separation through movement and pressure of the siliceous intruded matter. An interesting alteration of the felsite is to be observed on the summit of the hill lying $12\frac{1}{2}$ furlongs S. 15°—E. of Karadibetta. Here chocolate brown bands alternate with others pinkish to white in colour, the general appearance being that of a banded ferruginous quartzite.

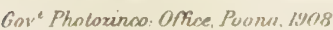
The colouration is due to the infiltration of ferric oxide along fractures, and subsequently along foliation planes and probably also to the oxidation of the concentrated bands of mica foliæ.

Certain bands in the series are of quite a gritty nature. One such was traced from the crest of the ridge $\frac{1}{2}$ mile S. W. of Karadibetta, southward for a mile, and again one mile S. E. of 2674. Many of the pebble like fragments are 1" in length. This deceptive impression appears to be due to the intrusion of felsite into a Quartz Porphyry.

An excellent illustration of banding in the felsite was observed 7 furlongs W. 10°—N. of Kundur. The rock
Banding. here becomes very massive and sharply cleaved W. 15°—S. These upper beds are fine, flint like in texture and of a dark bluish grey colour, while those lower in the series forming the higher central range resemble a silvery micaceous quartzite, the result of sheering.

The outcrops end abruptly between the villages of Tepgod and Midnagere, with the exception of a small exposure in the forest about 1 furlong North of the village of Jambani. The rock here is entirely silicified, the original fluxion structure only remaining. Fragments of quartz of a clear dark blue and opaque white up to an inch or more in size are enclosed.





**Report on the Iron bearing rocks in the neighbourhood
of Maddur and Malvalli.**

BY H. K. SLATER, F.G.S.,

Assistant Geologist.

The last five weeks of the Field Season of 1906-07 were spent in the neighbourhood of Maddur and Malvalli, where special attention was given to locating the beds of iron ore for which these parts have long been noted and on which a Preliminary Report by Dr. J. W. Evans, D.Sc., is published in Records Volume I.

The total area surveyed and mapped is 300 square miles which lies between Latitude $12^{\circ}45'$ and $12^{\circ}15'$ and Longitude $77^{\circ}20'$. The accompanying map shows how very small a proportion of the ground carries any outcrops of iron ore.

Over the greater part, practically, only shreds remain of what was originally a large area of intermediate and basic rocks. The hills across the Southern boundary of Mysore in the Coimbatore District may be taken to represent the nature of that which existed at one time many miles Northward, over country which now is mostly composed of granites and gneisses. The area surveyed may be divided into two portions—

- A. The Northern, divided longitudinally into the Western and Eastern.
- B. The Southern.

A. (i) The Western Area.

The Western consists of the oldest granites and rocks falling under the head of green stones, both penetrated by newer granites, which, during their intrusion have included fragments of the older rocks, the absorption of which has produced gneisses. A very uniform strike of N. 15° —W. and dip of 70° —E. 15° —N. is maintained throughout a large area, the rocks of which are mostly very decomposed and largely penetrated by veins of pegmatite. In the section afforded by the stream running from West to East commencing about a mile East of Malvalli, bands of the older granites,

crushed and mylonitized, are found alternating with fine grained grey gneisses containing large numbers of Hornblendic inclusions, which are of the nature of granulites, sometimes containing Hypersthene.

A. (ii) The Eastern Area.

The Eastern half consists of a fine grained pinkish gneiss, included in which are lenticular bands of intermediate rocks, chiefly granetiferous granulites and Hypersthene-Magnetite-Quartzites. Compared with the Western half it is hilly. A noticeable feature in most of the hills is an abrupt face and higher elevation at the Northern end, the whole hill gradually sinking towards the South.

The highest points are invariably gneiss, but on the shoulders of some may be found the remnants of the iron ore series.

Veinlets of a coarser pink granite, probably intrusions from the Channapatna granite range to the East, are frequent along the Eastern side of this belt.

B. The Southern Area.

The Southern portion extends along the Southern side of areas A., the Western and Eastern, and comprises all the country lying between the Malvalli-Kankanhalli road and the Cauvery river.

Except for the extreme Western portion in the vicinity of Malvalli where we have extensions of the oldest granites and pegmatites with numerous Hornblendic inclusions, it is composed of different members of the Charnockite series.

The predominating rock of the older series near the junction with the charnockites is one of intermediate chemical composition, of the nature of Diorite. The rock is usually characterized by sphene and a pale green pyroxene, definite beds are garnetiferous. When found as inclusions in the granites and penetrated by veinlets from them it is characterized by the presence of apatite and zircon.

Some few included blocks of this series in the gneiss, $7\frac{1}{2}$ furlongs N. 15° —E. of Hulvadi, carry grains of chrome garnet (Uvarovite), the other minerals present being diopside, felspar, humite, chromite and sphene. In another local phase of the series we have crystals of colourless Monoclinic Pyroxene lying in a matrix of lime in one

instance and scapolite in another. With the substitution of garnet we get an eclogite.

Another local metamorphosed phase is an Hornblendic garnetiferous granulite which passes into a garnetiferous mica schist.

I understand from Mr. Sampat Iyengar that this Dioritic rock is identical with that which Mr. E. W. Wetherell has called Tarurite. Two well marked beds of it occur associated with the Intermediate Charnockites. About a mile West of 2284 also, thin sheets, often not exceeding $\frac{1}{8}$ " , often occur alternating with the Charnockites; the latter is undoubtedly the more recent of the two and is therefore intrusive. A metamorphic effect is noticeable in the Diorite, *viz.*, the secondary mineral garnet is abundant and also scarcely a trace of the hornblende originally present is to be found, its conversion into secondary augite as described by Dr. W. F. Smeeth,* presumably having taken place. This phenomena was also observed in instances where the Intermediate Charnockites were intruded by the acid charnockite or Pegmatite.

Another rock apparently of this series is the garnetiferous Quartz-Magnetite-Pyroxene-granulite.

As previously stated the eclogite appears to be one phase and to that if Quartz and Magnetite be added we have one of the varieties of the iron bearing rocks of this region. Very occasionally feldspar may be one of the constituent minerals H₉/597, 598, 599. This rock occurs mostly in A, the Eastern area comprising the lenticular bands of schist that vary from a few feet up to 6 miles or so in length, but seldom exceeding 2 furlongs in width.

Charnockites.

The rocks of this series included in this area are of two types, the Acid and Intermediate.

The Intermediate phase so closely resembles an ordinary Hornblende schist in the field that one can never be sure of its identification without a thin section for microscopic examination.

* The occurrence of Secondary augite in Kolar Schists. Bulletin No. 3.

Of the two, the acid phase is by far the most largely developed, the intermediate variety occurring only as thin alternating bands or fragmented inclusions in the acid.

They are therefore seen to be of different ages.

The area occupied by this series lies chiefly to the South of the high road between Malvalli and Kankanhalli. The Northern limit of the acid phase as at present determined does not extend beyond a distance of 3 miles North of the road.

This Northern portion is largely intruded by the pink Channapatna granite, which, with the included fragments of Charnockite assumes a gneissic structure.

Intrusions of this pink granite form a portion of the hills S. E. of Halagur, largely penetrating the charnockite members on the Western spur. The Western boundary line may be drawn from near the 23rd milestone in a N. 15° —W. direction. It is here intercalated with beds of the Pyroxene Diorite.

Remnants of the Intermediate Charnockite composed of Hypersthene Magnetite and quartz were frequently found associated with, probably intruding the beds of, Garnetiferous-Quartz-Magnetite-Pyroxene-granulite, many miles North of the Mysore State Railway.

Dyke-like inclusions of Hypersthene granulites are not infrequent in the gneisses that have intruded the older granites to the East and North-East of Malvalli.

Wherever the acid Charnockite has been subjected to excessive pressure, we find garnets developed.

A mylonitic condition is not unusual, the stream running Northward between the 24th and 25th milestones, near Sivasamudram affords a good section across such beds.

So great indeed has been the pressure, in some instances that the rock simulates in appearance, a felsite of a chocolate brown colour. Bands of this were particularly noticed in 3 localities:—

- (1) immediately South of Hebbani, which bed may be traced Southward for $2\frac{3}{4}$ miles.
- (2) About 2 miles East 30° —N. of the 22nd milestone of the Malvalli-Sivasamudram road.

- (3) And again 6 furlongs S. E. of Netkal, where it has as its adjacent rock on each side the Pyroxene Diorite.

An ultra-acid phase of the Charnockite, or what might be described as Alaskite, is represented in a bed a few yards west of Δ 2276 and also in a much more massive bed that commences on the north side of Garakhalli ($7\frac{1}{2}$ miles S. E. of Maddur) and extends N. 10° —E. for a distance of $3\frac{1}{2}$ miles. The dip for the most part is almost vertical, though an angle of 75° —E. was taken.

Portions of this bed contain garnets, and certain bands are spotted with white felspars that lie corroded by the siliceous magma. In other parts sillimanite is the only mineral present besides the quartz.

On the northern slope of the hill one mile W. N. W. of Δ 2392 it was found associated with the Garnetiferous-Quartz-Magnetite-Pyroxene-Granulite and Pyroxene Diorite.

Iron-bearing rocks.

In this region we have three varieties of iron-bearing rocks from which the metal may be obtained, but in all cases crushing and separation would be necessary.

Varieties.

- (a) Intermediate Charnockite composed of Hypersthene, Magnetite and Quartz.
- (b) Garnetiferous-Quartz-Magnetite-Pyroxene-Granulite.
- (c) A mylonitized rock containing phenocrysts of garnet, Monoclinic and Rhombic Pyroxene, set in an opaque Magnetite base, intruded by stringers of silica.

The first variety, of which H₉/633 represents an average from many samples, *viz.*, H₉/28, 106, 181, 194, 216, 217, 218, 251, 253, 254, 255 and H₉/634 an average of a schistose phase of the same rock represented by H₉/376, 377, 378, 379, 436, 437, is that which appears to have been formerly worked for iron, but only in its decomposed friable state which rendered crushing and separation easy.

The hypersthene in this has all decomposed, leaving only the separation of quartz and magnetite which was no doubt easily

effecte by panning. The magnetite sand liberated by nature and found in the nullas was also used.

The first two varieties *a* and *b* often occur together as long narrow beds in the fine-grained pink gneiss which intrudes and abruptly terminates them, wherever found to the north of the Shamsha river. The proportion of *a* to *b* is very small. The outcrops are so small and numerous that their position is best grasped by reference to the accompanying map. To the south of Halagur where the Charnockite Series is less cut up, attention may be drawn to a few outcrops of the Pyroxene-Magnetite-Quartzite.

About a mile E. S. E. of Karalkatte, about 6 beds a few feet in thickness alternate with the Intermediate Charnockite. Further reference to these is made under "Old workings." A fairly strong outcrop crests the hill 5 furlongs S. W. of $\Delta 3402$, smaller exposures being also found $\frac{1}{2}$ mile and 1 mile 3 furlongs west of $\Delta 3402$. The most continuous bed of this variety immediately overlies the acid charnockite, which forms the western side of the fairly continuous low ridge having $\Delta 2381$ as its central peak; and lies on the eastern side of the Shamsha river (referred to by Dr. Evans on page 13 of Records, Vol. I). It has been found to continue southward for a distance of $3\frac{1}{2}$ miles further than the point observed by Dr. Evans, which gives a length of outcrop of $8\frac{1}{2}$ miles. The northern half of this series is a good deal disturbed by the intrusion of the acid charnockite, in fact at two points, *viz.*, immediately south of the high-road between Halagur and Malvalli and about $\frac{3}{4}$ mile W. S. W. of Yalarchigere; the beds are cut out altogether for a distance of $\frac{1}{2}$ mile in each locality.

I consider these beds together with the remnants of a parallel series lying about $1\frac{1}{4}$ mile to their east to be economically the most important. The low line of hills will for convenience be referred to as the "Karalkatte ridge." It has been worked at intervals for over a distance of 5 miles.

This rock ($H_9/633$) contains on an average about 37 per cent matter separable by a magnet the greater portion of which is probably magnetite and the schistose phase ($H_9/634$) about 72 per cent.

(b) Garnetiferous Quartz-Magnetite-Pyroxene-Granulite.

As stated above, this variety forms all the detached out-crops of schist in the gneissic area to the north of the Shamsha River and a few small outcrops to the N. E. of Husugur and S. E. of Hullahalli.

It also forms the uppermost bed of the Karalkatte ridge and also the outcrops referred to by Dr. Evans as "the most extensive" lying about 3 miles S. E. of Malvalli.*

The main bed extends from the 24th milestone on the Malvalli-Sivasamudram road to within a couple of furlongs E. S. E. of Hebbani. Remnants of the bed are found on the small hill south of the road very largely intruded by granite. It was not followed south of this point, but Dr. Evans states that it extends as far as the Cauvery.† This rock contains 45 per cent of Magnetite, and is represented by the following specimens:—

H₉/3, 6, 59, 87, 98, 99, 105, 182, 183, 184, 185, 186, 187,
188, 189, 190, 202, 203, 214, 215, 233, 234, 249, 305,
382 and 590.

(c) A mylonitised rock containing phenocrysts of garnet Monoclinic and Rhombic Pyroxene set in a Magnetite base intruded by stringers of silica. This third variety is associated with the two foregoing and forms a bed of about 20 feet in thickness lying between (a) and (b) and extending practically along the full length of the Karalkatte ridge.

Another outcrop of this rock, about 1 $\frac{3}{4}$ mile in length, commences 3 furlongs N. N. W. of Hebbani and extends northward passing through the village of Chetanhalli.

This contains on an average 64 per cent of magnetic matter, and is represented by H₉/311, 312, 313, 314, 315, 317, 318, 322, 393, 481, 586, 587, 588, 589, 592, 595, 598, 599. The specific gravities of the three varieties (a), (b) and (c) do not appreciably differ, the three maintaining an average of 3·6.

* Records of the Mysore Geological Department, Volume I.

†

Ditto

ditto.

Magnetite.

Magnetite occurs as small veins in some of the outcrops of the Garnetiferous Quartz-Magnetite-Pyroxene-Granulite. It is not often that the actual veins are seen, but small fragments varying from $\frac{1}{4}$ "—1" in thickness and represented by H₉/200 are sometimes to be observed scattered over the surface of the ground, as over a small area lying three furlongs south of Tippur and also on hill 2337. A very much larger vein of Magnetite represented by H₉/ 521 and 13—9·10·11·12 contains about 72 per cent of Magnetite. It commences about one mile north of Δ 2249 or one mile W. N. W. of the Gangana Chukki Fall, with a width of about 12". It was traced fairly continuously for a distance of six furlongs to the N. N. W. at a distance of about 20 yards from the western side of a very fine-grained Olivine Enstatite dyke which also lies parallel with the general N. N. Westerly strike of the rocks. Indications of the continuance of this vein were observed about $\frac{1}{2}$ mile south of Δ 2284. The Magnetite vein lies in the acid Charnockite and probably represents an ultra-basic phase of that series.

Appended to this Report will be found a statement of the percentages of magnetic material, determined by means of a small hand-magnet from crushed samples of some of these rocks, others distinguished by the letters B and O, being larger samples collected from the same outcrops by one of the Prospectors. The results must, however, be regarded only as approximate in value.

Greater care was given to the separation of 0/261 which represents the Pyroxene Magnetite Quartzite formerly worked, from 3 furlongs S. E. of Byadarhalli.

The process followed in this case is as under:—

One hundred grms. of 0/261, which had been crushed and passed through a 30-mesh sieve, were taken and sieved through 60-mesh.

The material remaining on the 60-mesh yielded 27·02 grms. of magnetic material.

Both this and the non-magnetic residue were crushed and passed through 60-mesh and again taken up by the magnet; the

former was found to be reduced by 3.65 grms, while from the latter 1.38 grms. of magnetic matter was obtained. From the matter which originally passed the 60-mesh, 30.2 grms. of magnetic matter was obtained, giving a total for the whole sample of 54.95 per cent ($23.37 + 1.38 + 30.2$) of magnetic material.

In some cases the amount of Fe, FeO and Fe_2O_3 have been obtained chemically for the whole samples and for the magnetic and non-magnetic portions; these figures are also given in the Appendix.

Old workings for Iron.

In the centre of the small group of hills lying about 6 furlongs S. E. of Hullahalli near the crest of the hill, is a trench of about 8 feet in width by 100 feet in length running parallel with the N. and S. strike of the Garnetiferous-Quartz-Magnetite-Pyroxene-Granulite. This was worked for iron about 50 years ago; work was terminated owing to a fall of rock which caused the death of ten men.

A fair amount of excavation has also been carried on along the western side of the Karalkatte ridge about $1\frac{3}{4}$ mile S.W. of Hala-gur. The locality was favourable for panning the crushed material as the Shamsa river flows not more than a couple of furlongs distant.

The rock here as elsewhere excavated was the Hypersthene-Magnetite-Quartzite, in its decomposed state.

The underlying rock is the acid Charnockite and the overlying bed which has a thickness of about 20 feet is the Mylonitic Iron-bearing rock already referred to.

Along the same low ridge about $\frac{1}{2}$ mile S. 15° W. of Karalkatte is another trench $20 \times 10 \times 8$ in size. The bed worked is probably a continuation of the one worked to the N. N. W.

Following the crest of this ridge southward the next workings are found beyond Δ 2381 as a series of 4 or 5 pits, 5-6 feet in depth. The small hill one mile E. 10° S. of Karalkatte has been pitted all over; dumps are also to be found shewing that the crushing was done on the spot.

Thousands of angular blocks of the Hypsthene-Magnetite-Quartz rock partially fill in most of the pits. The bed is practically cut off by granite near the large nulla to the north, but reappears on the north side with a very low dip. Granite underlies it with a dip of 10° — 15° . It has further been worked both to the north and south of the next small stream that crosses it ($6\frac{1}{2}$ furlongs W. 30° N. of Karalkatte). It can be traced still further northward for another $\frac{1}{4}$ mile, but is very shallow, the underlying granite shewing close to the surface.

Three thin beds of this rock associated with the acid and Intermediate Charnockite can be disconnectedly followed for a distance of $2\frac{1}{4}$ miles southward of the first-mentioned hill and one mile E. 10° S. of Karalkatte.

Beyond this the country was not surveyed. A small amount of work has also been done in the northern area at the following localities :—

- (1) On the small hill 6 furlongs W. 30° S. of Timsandra.
- (2) Two and half furlongs N.W. of $\Delta 2531$.

The pits here are very shallow and whatever was originally extracted could only have existed in small quantities possibly as veinlets, though from any information now available, such were never worked. Hundreds of angular blocks of the Garnetiferous-Quartz-Magnetite-Pyroxene-Granulite are left untouched, and from the manner in which they are broken, the separation of veinlets of Magnetite is certainly suggested.

- (3) Three furlongs S. of Tippur or 9 furlongs S.S.W. of $\Delta 2531$.
- (4) A small amount of excavation has also been carried on at the southern end of hill 2595, the first locality referred to by Dr. Evans in his Preliminary Report.*

* Records of the Mysore Geological Department, Volume I.

Smelting.

Iron slag was noticed at the following localities :—

- (1) At the northern base of $\Delta 2392$, but only as a few stray pieces.
- (2) Four furlongs E. S. E. of Hullahalli, a village where smelting is reported to have been carried on.
- (3) The largest mounds of slag observed are those $\frac{1}{2}$ mile west of Husugur, and traces $1\frac{1}{4}$ mile W. 15° N. of the same village near the small temple that stands on the south bank of the stream.
- (4) No information of smelting ever having been done at Halagur could be obtained, but it was undoubtedly carried on near the village of Byadarhalli, about 2 miles south.

Dykes.

The dykes in this area are of both acid and basic varieties.

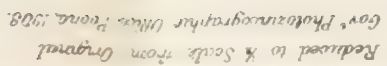
1. The acid dykes consist of red Porphyry similar to those in the Seringapatam Taluk and comprise only two types :
 - (a) With a ground-mass of Felspar containing Phenocrysts of Hornblende and occasionally Quartz and Porphyritic crystals of Felspar.
 - (b) With a ground-mass of Felspar and Hornblende and Porphyritic crystals of both minerals. They maintain an average strike of E.N.E. and are confined to the southern portion of the area under report.
2. The basic dykes consist of three varieties :—
 - (a) Dolerite with only Monoclinic Pyroxene.
 - (b) Dolerite with Monoclinic and Orthorhombic Pyroxene.
 - (c) Dolerite with the addition of Olivine.

(a) and (b) are found striking N. 35° W. and E. N. E., while (c) is represented in two dykes of importance one of which commences about a mile north of Makkunda and was traced N.W. for a distance of 7 miles. The second commences not far from the Gangana Chukki Fall and strikes about N. N. W. It is probably connected with the dyke cresting $\Delta 2284$ which is similar in composition.

Cromlechs.

Stone circles usually some 15 feet in diameter are not uncommon in this region.

An interesting set of half a dozen cromlechs are to be found along the crest of the low ridge 3 furlongs W.S.W. of Karalkatte. Most of these have been opened some years ago, and found to consist of a stone chamber about 8 feet square, each side and top being formed by a single slab of granite. A few other circles were noticed 2 furlongs S. E. of Δ 2203, apparently undisturbed.



APPENDIX.

Magnetic separation of some samples, etc.

In the following statement, the three varieties of the iron-bearing rocks will, for convenience, be referred to by the letters A, B and C—

A, representing the Hypersthene-Magnetite-Quartzite ;

B, the Mylonitic-Garnetiferous-Pyroxene-Schist ;

C, the Garnetiferous-Quartz-Magnetite-Pyroxene-Granulite.

The four following samples of these varieties represent average samples of many specimens collected from the different outcrops of the respective rocks :—

H_o/633 (A) yields 37'68 per cent of Magnetic material.

H_o/634 (A), the same variety, but schisted and compressed from the Karalkatte ridge=92'49 per cent.

H_o/635 (B)=54'07 per cent, H_o/636 (C)=23'91 per cent.

Other individual samples of A are as follows :—

H_o/188 from 3 furlongs N. W. of Iggalur, 66'12 per cent.

H_o/251 from 1½ miles east of Yelachigere, 60'92 per cent.

O/260 from ¾ mile east of Karalkatte, 44'32 per cent.

O/261 from 3 furlongs S. E. of Byadarhalli, 54'95 per cent.

O/261 Chemical analysis of two samples { (a)=Fe. 62'30 per cent.
(b)=Fe. 66'37 per cent.

B/18 from the Karalkatte ridge (Δ 2381), 64'71 per cent.

The remaining samples represent the vein of Magnetite Hæmatite ¾ mile west of the Bluff, Sivasamudram. The portion unattracted by the magnet is chiefly Hæmatite.

H_o/521 Chemical analysis of { Whole sample Fe=56'48.
Magnetic portion Fe=68'05.

B/9 Chemical analysis of { Whole sample { FeO=18'78
Fe₂O₃=63'37 } =Fe. 59'91.
Magnetic portion Fe=64'70 per cent.
Residue { FeO=20'72
Fe₂O₃=46'29 } =Fe. 48'45.

B/10 Magnetic separation=84'12 per cent—Fe=60'59.

B/11 Ditto =85'12.

B/12 Magnetic separation=67'72.

B/13 Ditto =79'26—Fe=34'94.

This contains a large quantity of manganese.

B/14 Magnetic separation=59'82.

H₉/200 represents the veinlets of magnetite occasionally found traversing the Hypersthene-Magnetite-Quartzite.

Magnetic separation=71'6—Fe=63'62.

Chemical analysis of { Magnetic portion Fe=70'81.
Non-magnetic portion Fe=59'18

Report on the Geological Survey of portions of the Mysore District for the year 1906-07.

BY B. JAYARAM, F.G.S.,

Assistant Geologist.

Introduction.

During the field-season of 1906-07, I was ordered by the State Geologist, Dr. W. F. Smeeth, to do a rapid Geological Survey of the South-Eastern corner of the Mysore District.

Accordingly, I commenced work towards the end of December 1906, and closed it on the 7th of June 1907, during which period an area of over 800 square miles was examined and mapped in the taluks of Nanjangud, Yelandur, Gundlupet and Chamrajnagar.

Considerable difficulty was experienced in traversing Gundlupet and Chamrajnagar taluks, owing to their hilly character with thick elephant forests and tall grass which often attained six to eight feet in height—thus rendering walking and observation difficult.

I wish to acknowledge the great assistance I have received from the Amildar of Gundlupet, Mr. Krishna Urs, and the Range Forest Officer of Chamrajnagar, Mr. N. Chinniah Chetty, who gave very material help to facilitate my movements and survey-work while examining the Biligirirangan range of hills.

OBJECT OF SURVEY.

A preliminary mapping in of the broad geological features of this area, many portions of which had not hitherto been explored, was the main object of this survey.

To accomplish such work over an area of 800 square miles of country, many portions of which were extremely difficult to get about in, with anything like accuracy and satisfaction, would naturally require the geological formation of the area to be reasonably simple.

As a matter of fact, the region is almost entirely composed of old Archæan gneisses and granites and crystalline schists, whose

original characters have been greatly altered by subsequent earth-movements and intrusions, and the results obtained from the preliminary survey are necessarily very incomplete and, though of considerable importance, they will doubtless bear much future revision.

The area has been mapped on a scale of 1 mile to the inch and a copy of the map is kept at the Head Office in Bangalore for reference. A map, on a reduced scale of 4 miles to the inch is published with the Report (Plate III) and shows the chief features of the area.

In describing this field-season's work, I have thought it very desirable to make use of the information gathered during the previous years' survey conducted in other parts of the Province for the purpose of correlating the various rock types and showing their general distribution.

In describing the details of the area surveyed, I propose to divide my remarks into two sections, the first dealing with the general geology of the areas included in the various Topographical Survey Sheets of the Nanjangud, Yelandur, Gundlupet and Chamrajnagar taluks; and the second dealing with the petrographical considerations of different lithical and petrical types that are found not only in the above area but also distributed in other parts of the State.

Brief outline.

The map (Plate III) includes the country lying between $76^{\circ} 30'$ and $77^{\circ} 30'$ East Longitude and within $11^{\circ} 30'$ and $12^{\circ} 15'$ North Latitude, and portions of Nanjangud, T.-Narsipur and Yelandur and the whole of Gundlupet and Chamrajnagar taluks. It shows the political boundaries of the southern portion of the Mysore State on the east, south and south-west; these with the physical features of the area will be described in detail under Section 'A.'

The general strike and dip of the country varies considerably. Towards north, near Talur and Shinduvalli, the strike is nearly north and south and the dip on some beds is to the east and on others to the west. In

Area.

Strike and dip.

the neighbourhood of Nanjangud, the schist bands strike as much as 45° — 50° east of north and dip 50° — 60° to the south-east; while near Valgere the strike is not so many degrees to the east and the dip is 60° — 70° to the west. Further south the schists are folded, where the strike and dip vary with the curvature of the fold. The dips are lower 30° — 40° and point inwards, *i. e.*, the eastern limb of the fold dips to the west, the northern to the south and the western to the east. This inward dip or sagging of the folded schists seems a common feature with a great many of these folds.

In the vicinity of Gundlupet, the strike is E.N.E. and W.S.W. and the dip to the S.S.E.; they become almost east and west and to the south, respectively, on beds near Jakanhalli and Moyar river.

Towards east and north-east the strike bends back to 20° — 10° east of north on the Charnockite masses which dip steeply 70° — 80° to the east.

A cursory glance at the map will show that a very large extent of the area is composed of granites and gneisses. These have been observed to present local variations in texture and composition, and in particular cases, good evidence of their intrusive character. But for want of clear junctions, definite boundaries, distinct petrological differences and mappable areas, I have been unable to differentiate them on the map, with the exception of the charnockite series, which has been given a distinctive colour and symbol and shall be described under a separate heading.

The oldest member of these archæan granites and gneisses appears to be the fine-grained muscovite-biotite gneiss, which may for brevity be referred to as the Nanjangud gneiss, and which has acquired a perfect fissile character on ridge south of Jakanhalli and on the northern banks of the Moyar river, where the dip is steep, 70° — 80° to the south.

This fissile character of the gneiss near Jakanhalli is largely due to the intimate banding of the lighter aplitic and quartzose veins.

Veins of a pink granite penetrate the gneiss in the river
 Kaganhole south of the Police Station (P. S.),
 and on hills S. E. of $\Delta 4769$.
Younger granites.

Also a coarse uniform granite is intrusive into the fissile gneiss along the track going down the steep hill-side into the Moyar river, from 2619 app. to 1682 app. This granite has been invaded by pegmatites and aplites of still later origin and has subsequently acquired a pretty mylonitic structure.

Besides, there are lighter aplitic granites which have been described as the quartz-felspathic granites and darker hornblende-granitic bands as the quasi-charnockites in the Gundlupet area.

In the neighbourhood of Sargur, the gneiss is characterized
 by metamorphic minerals, such as Cyanite,
 Staurolite, Garnet, etc., and the hills round
 about this locality appeared to be very rich in Quartz-magnetite rocks.
Metamorphic gneisses.

Lenticular masses and bands of gneiss are frequently associated with folded schists when they occupy the central position. They are rich in garnets and biotite of the hautonite species; sometimes in cyanite and sillimanite with rutile.

On the eastern edge of the map, these rocks are well developed
 and form the Biligirirangan range of hills.
Charnockites.

Towards south they continue and evidently form the Nil-
 giris; their northern continuation forms the
 Sivasamudram range of hills, where the series
 have been previously observed by me to be highly crushed and
 penetrated by the Closepet pink granite.
Distribution.

(The latter point is interesting and I hope to be able to confirm or correct this observation in future survey work.)

Towards west, massive charnockite has not been found though a few hypersthene-bearing basic intrusives have been noted. Presumably it occurs further west and runs up north into Coorg.

So that the distribution of these rocks conforms to the V-shaped configuration of the South Indian Peninsula.

The mapping of this series round about Punajur and Jotigowdanpur suggests the bifurcating character
 of these rocks. Inclusions of biotite gneiss
Relative age.

and hornblende granulite schist in them afford further proof to infer that they are younger to the above two rocks. Moreover, the lenticular masses and bands belonging to the charnockite series that are scattered in the neighbourhood of Chamrajnagar, Kabhalli, Kottalvadi and Arakalvadi, have been observed to lie obliquely to the foliation strike of the gneiss and the schists—thus confirming their intrusive character and younger origin.

Apparently resting on, though older than, the above granites and gneisses are numerous thin bands and small shreds of hornblende granulite schist, which has been split up and invaded by granitoid-gneisses.

They are scattered throughout the area, but the largest is the band north of Alattur. It is probably a broken continuation of the Valagere band.

As these thin schist bands are frequently found in junction with the granites and acid veins, their contacts are invariably characterized by a strong development of hard augitic bands and calcite-lenses.

Associated with the schists are lenticular masses and patches of gray pot-stones and ultra-basic rocks, quartzites merging into quartz-reefs, which are sometimes comparable to the alaskites, and ferruginous rocks.

In the neighbourhood of Alattur, the complex is further complicated by a set of hornblendic runs which have been separated from the hornblende schist and mapped as "altered hornblende dykes."

In the Gundlupet area near hills $\Delta 4133$ and $\Delta 4769$ a number of hornblende-diorite looking masses puzzled me considerably. In the field, they resemble somewhat the basic charnockite, but under the microscope, their sections do not show any recognizable hypersthene, though their hornblendes, felspar, ilmenite and apatite show strong affinities with that family of rocks.

I do not think that they are altered hornblende schist, since they are conspicuously free from sphene and other secondary minerals which characterize the modified schists.

For the present I have separated them from the two series and have described them under the heading 'Quasi-charnockite.'

The country has been traversed by two sets of dolerite dykes—the one striking north and south nearly, and the other east and west. Some of the latter have been noticed to cut across the former.

Dykes.

The hypersthene-bearing charnockite-granulite dykes are not characterized by any chilled edges and are traversed by the dolerite dykes.

Dykes of felsite or quartz porphyry have made themselves conspicuous by their absence.

No special attention was devoted to the finding of economic minerals, with the exception of examining the trench put down by Mr. Randolph Morris for ruby corundum near Badavadi and the chromite-magnesite deposit near Talur and Shinduvalli. A note on these will be found in my detailed report.

Economic geology.

Kankar occurs in thick deposits all along the banks of the Gundlur river and earth-salt along the river Mugur. Both have been worked for on a small scale—the latter nearly dying out.

“SECTION A.”

General Geology of parts of Nanjangud, Yelandur, Gundlupet and Chamrajnagar Taluks:—

For convenience and ready reference, I will treat the subject with reference to the five topographical sheets which include the above-noted taluks, and not by the taluks separately.

The sheets are as follows:—

	Serial number	East Longitude	North Latitude
1.	79 (58)	76° 31' to 77°	12° to 12° 15'
2.	80 (68)	Ditto	11° 45' to 12°
3.	81 (69)	Ditto	11° 30' to 11° 45'
4.	111 (70)	77° to 77° 30'	11° 45' to 12°
5.	110 (62)	Ditto	12° to 12° 15'

1. “SHEET 79 (58).”

This includes the country lying between 76° 31' and 77° East Longitude and between 12° and 12° 15' North Latitude and portions of Mysore, T.-Narsipur and Nanjangud Taluks.

Physical features.

The country is typically undulating in character, in which are preserved quite a number of low hills. In height, the latter range from 2,300 to 3,094 feet above the sea-level; the lowest point recorded being 2,116 app., the greatest vertical height observed can only be 978 feet.

The river Kabbani forms the largest natural drainage. It runs from west (near south of Hommargalli) to east of the sheet with an east-north-easterly meandering course and mingles with the river Cauvery at T.-Narsipur, where they form a wide lake over three furlongs in breadth. This confluence is considered holy and many Hindus from different parts of the Province resort there for the sake of bathing. Hence the renown of T.-Narsipur as a place of pilgrimage and the seat of taluk head-quarters.

Not only does the river Kabbani illustrate the characteristic meandering course, but all its tributaries wind in serpentine curves in a striking manner. This feature is peculiar to countries which are tolerably level or undulating.

Among the many 'feeders' into Kabbani, three of the chief ones may be mentioned. These are the 'Nugu,' 'Gundal' and 'Mugur,' though the last ought to be looked upon as a tributary directly feeding into the big river (Kabbani plus Cauvery) near the bend just north of the Yelandur boundary.

Geology.

Dr. Smeeth, in his Report of the Chief Inspector of Mines in Mysore for the year 1901-02, has published an account of his inspection of the work done by me in the neighbourhood of Ambale and Valagere.

Mr. Primrose has also published two plates showing the general geology and magnesite deposits near Mavinhalli and Kadakola (Plates VI and VII, Records Volume IV).

During this field-season and towards the end of Dr. Smeeth's inspection tour, we visited the Magnesite and Chromite deposits occurring on rise between Shinduvalli and Talur,

Some specimens were collected from the chromite bearing rocks which have not yet been thoroughly examined, but from a study of similar rocks found in other localities, a few remarks may be made on the general geology of this area.

The common rock of the country is a biotite gneiss with a foliation strike of 10° and a dip of 60° — 70° left (west). It is much banded with aplitic veins and runs of hornblendic material, some of which is banded hornblende granulite and some very spheroidal and homogeneous. The former may belong to the age of Kolar schists, while the latter to a subsequent age of altered dykes, which are sometimes seen striking slightly obliquely to the gneiss.

Besides, there are some runs of ultra-basic rock which has been more or less altered to 'pot-stone.' The pot-stone itself occurs in small veins, which appear to run across the gneiss.

The largest outcrop of ultra-basic rock runs almost north and south, occupying the rising ground midway between Shinduvalli and Talur. It is a couple of miles long and is about 60 to 70 yards wide. It is much veined with magnesite and is shot with specks of chromite. The latter is also seen lying in long lenses or veins up to two or three feet in thickness, which have been opened to a depth of 15 feet, half-a-mile south of the cart-track.

Crossing the formation are some small veins of greenish-grey pot-stone and green olivine rock. The latter probably represent ramifying offshoots from the two olivine dykes which are running nearly north and south (340° — 350°) one furlong and three furlongs east, respectively.

These cross-features are not traversed by the magnesite though sometimes broken up by kankar of which there is a good deal.

On ridges three and four furlongs south and north-north-west, respectively, of Talur are outcrops of massive pot-stone merging into, or intimately associated with, ultra-basic rock. That south of Talur is striking as much as 30° to 40° west of north, while the hornblendic and gneissic bands are trending somewhat

east of north—thus affording the only reliable field evidence to determine their relative ages.

These masses are associated with more kankar and less magnesite; and chromite specks are discernible in the gray pot-stone.

A good section showing the different rock types occurring in alternate bands is obtained on the rise four furlongs north of Dod-Kattur.

Commencing from the cart-track and walking east across the ridge as far as the stream, the following may be observed:—

- (a) Pot-stone comparable to my series of graystones (Records, Volume VI, pp. 48-50).
- (b) Band of hornblende granulite schist probably belonging to the Kolar series.
- (c) Another band of pot-stone.
- (d) Biotite gneiss.
- (e) Ferruginous-quartz-schist.
- (f) Quartz-vein with-secondary augite.
- (g) Ferruginous-quartz-schist.
- (h) Biotite-gneiss.
- (j) Ultra-basic rock altered.
- (k) Hornblende granulite schist.
- (l) Biotite-gneiss.
- (m) Ultra-basic rock in which chromite has been worked for and magnesite is conspicuous.

(e), (f) and (g) may be looked upon as one band of hornblende granulite schist, which has been modified by intrusive quartz veins.

The beds (a) and (b) have a dip of 75° to the east and the rest a dip of 70° to the west.

Conclusion.

From a consideration of the foregoing observations and from a knowledge of the geology of the country around Nanjangud, some conclusions regarding the structure of the country may be deduced.

Granting that the commonest rock of the country is a biotite gneiss and that some of the dark hornblende granulite schists are

modified remnants belonging to the Kolar series of metamorphosed basic lavas, it is not easy to say which of these two is the oldest. Nor is this difficulty experienced over this particular area alone; on the other hand, I have felt it throughout my survey work.

In fact, I must faithfully confess that I have never yet been able to lay my hands on any distinct gneiss, which is consistently underlying or not intrusive at some point or other into the true hornblende schist; while the latter has always been observed to lie with the gneisses as parallel bands or ex-foliated patches and lenses, or caught-up fragments and invaded masses but never intruding or running obliquely into any gneiss or other formation.

So, I have not yet proved the existence of any archæan formation older than the hornblende schist of the Kolar series; nor have I found any means to prove the non-existence of some gneiss, which may, for all I know, be the floor on which these hornblende rocks originally flowed over.

In default of any evidence to make the hornblende schist a younger rock, I am compelled at present to recognize it as the oldest known member presumably resting on an hypothetical archæan basement rock, say gneiss.

After the above general statement which will be applicable to the whole area under consideration, I will return to the particular locality in question.

Here some of the dark hornblendic bands belong probably to the oldest known series. Next in age comes the gneiss "whose structure may be due to the irregular cooling and crystallization of large granitic magma, accompanied by pressure from east and west before complete solidification took place and followed by the intrusion of the residuary veins of pegmatite, of still later origin, which wander through the gneiss more or less along the general direction of the banding." (Report of the Chief Inspector of Mines in Mysore for 1901, page 13.)

To this period belong the intrusions of siliceous material into the hornblende schist, which has locally been changed into augitic and ferruginous-quartz-schists.

Subsequent to the above, ultra-basic and pot-stone members appear to have been irrupted through fissures and spread over a large tract of the country. Then some of the spheroidal homogeneous hornblende granulites must have welled out as dykes through rents and these have been traversed by granitic material of still later origin.

At this stage, renewed pressures from east and west must have operated on the whole series, which has consequently acquired the present folded and interbanded structures and lost to a large extent their original character.

As the result of these many eruptions and renewed pressures, the country has been further fissured in different directions. These vents are now occupied by dykes of dolerite and 'porphyry.' Among these some of the north and south dykes have been cut through by the east and west ones, while some dykes of porphyry striking E. N. E. in the Halagur vicinity have been proved to be intrusive into the dolerites.

The continuity of these dykes over long distances and their tolerably unaltered condition, when examined in slices, warrant a safe conclusion that the country has not been subjected to any great earth-movement since their advent.

In the above paragraphs no allusion has been made to the
Origin of magnesite,
chromite and kankar. epoch of magnesite-chromite and kankar formation.

There are suggestions that the ultra-basic rocks and pot-stones are genetically similar, and both have been observed to contain chromite-specks.

The presence of magnesite running as veins in the ultra-basics and the absence or paucity of the same mineral in the pot-stones would go to show that the composition of these rocks, even if they belonged to one and the same series, must vary.

The intimate association of magnesite and chromite in a highly altered ultra-basic rock would naturally lead one to suspect the original composition of such a rock to approach one of "dunite."

If such a composition is conceded to these ultra-basics, then the formation of chromite belongs to the primary consolidation of a magma essentially composed of olivine and chromite.

Dunite composition.

The ore-bodies of chromite occurring in veins or lenses may be due to differential segregation accompanied by secondary enrichment relating to the period of olivine metamorphosis.

Chromite.

The magnesite formation along irregular cracks and veins must have accompanied or followed the alteration of the unstable mineral olivine.

Magnesite.

In the manufacture of magnesite, it is not quite easy to understand how much of the CO_2 that went to combine with the magnesite of the olivine belonged to the igneous emanations and how much to the meteoric waters.

The formation of kankar is more wide-spread and is associated not only with the above rocks, but also with the hornblende schists and gneisses. Here the meteoric waters carrying CO_2 have had a great deal to do with the lime carbonate production.

Kankar.

The lime-carbonate formed in and near basic rocks is easily distinguished from that developed in the gneisses.

In the latter, one always finds clear grains of quartz, which naturally yield to very little weathering or decomposition, and kaolinized sites of felspar, which readily break down under atmospheric action, as ghosts or remnants of a disintegrated granite; while in the former some dark ferro-magnesian constituents or remnant schist lenses or bars appear in place of quartz and felspar.

Derived from basic rocks and gneisses.

Besides, crystalline calcite veins and lenses occur as contact products in the basic rocks and seldom or never in the gneissic area.

The geology of the rest of the sheet needs no further mention except that near $\Delta 2501$ and near the 2nd mile north-east of Kavalandê there are pyroxene-granulites containing hypersthene, which may belong to the charnockite series.

2. SHEET No. 80 (68).

This is the southern continuation of the above-described sheet 79 and includes the country lying between the same east longitude, but between $11^{\circ} 45'$ and 12° north latitude.

It contains parts of Nanjangud, Gundlupet and Chamrajnagar taluks and comprises an aggregate area of about 540 square miles.

The general geology of the sheet may be briefly outlined under three sections, namely :—

The 'Western,' 'Central,' and 'Eastern.'

The Western Section.

Compared with the country already described and with the 'Central' and 'Eastern' sections, this belt of country is strikingly more rugged and hilly with forests getting so thick in the neighbourhood of Hekkonbetta range of hills that elephants frequent these parts during the cold months of the year—November and December.

All the hill-streams join together and eventually find their way into the rivers Nugu on the west and Gundal in the centre.

The lowest level recorded is 2,244 feet app. near the bend of Nugu river and the highest Trig. Station is 3,732 feet above the sea-level; so that the greatest vertical height is a trifle less than 1,500 feet.

The prevalent rock of the country is a biotite gneiss, which has already been described. Besides, there are locally developed dark gneisses characterized by hornblende and sphene, which are foreign to the biotite-gneiss. They are found in the neighbourhood of hornblende granulite schist. The field-relations of these two are such as to warrant an inference that the biotite-gneiss is intrusive into the hornblende schist, and that the dark gneiss represents considerable interaction between the invading and invaded rocks, wherein the former has fused and absorbed hornblende and titanium materia from the latter.

In the neighbourhood of Sargur and Mullur the gneiss is characterized by metamorphic minerals such as cyanite, staurolite and rutile. This hilly region is well worth close examination and prospecting, since a hurried traverse showed me huge outcrops of "Quartz-magnetite" and "pockets" rich in metamorphic minerals.

Though local modifications and difference of composition and texture presented by the granites and gneisses have been noted, yet it was found almost impossible to differentiate them for stratigraphical purposes.

Treating the above-described as forming one granite or gneissic complex, a brief mention will be made of the other rocks composing it.

Among them hornblende schist predominates. It occurs in thin belts or bands and broken-up shreds and lenticular masses. Intimately associated with this are "quartz-felspar" reefs, which merge into reefs of quartz and quartzites, quartz ferruginous schists, the so-called "tarurites," and veins or exfoliated lenses of calcite.

Alternating with the above and not infrequently lying obliquely to them are the "graystones and schists" and ultrabasic masses.

In the neighbourhood of Alattur there are a number of long lenticular hornblendic runs, which have been mapped as altered basic intrusives. They are non-schisted and homogeneous and present a somewhat different look to the true hornblende schist with which they are associated. Their squeezed-out, parallel, lenticular shapes following the foliation or weak planes are in keeping with the behaviour of intrusive masses which are subjected to deforming lateral pressures.

The existence of six or seven fairly big dolerite dykes running nearly north and south (though crossing the rest of the formation here and there) is a further proof of the lateral pressures having determined the direction of these intrusives.

Towards south and south-west some of the hornblendic masses became confoundedly confusing, so much so that I did not know whether to map them as "portions of hornblende schist that

**Sargur hills interesting
for iron-bearing rocks.**

**Lenticular runs of al-
tered hornblende dykes.**

had been altered into coarser dioritic-looking rocks," or "as altered hornblendic intrusives" or whether to understand them as basic "schlieren" or portions belonging to some granite magma.

As some of these present striking similarity, both in the field and under the microscope, to the basic members of the charnockite series, and since they and their granites including them do not contain hypersthene, I have separated them from true charnockites and shall describe them later on under the heading "Quasi-charnockite."

The general strike of the country varies from north and south to as much as E. N. E. to W. S. W. the change determined by the folding and general curvature of the massifs.

The dip ranges from 40° to 60° to the east though frequent fluctuations in its amount and direction have been noted on outcrops thrown into sharp or gentle folds.

Central Section.

This occupies the level stretch of country showing the main road from Nanjangud to Gundlupet. About two miles east of the road runs the river "Gundal" almost north and south.

The area is chiefly gneissic which is strongly featured by a thick deposit of kankar.

Between Dodadhalli and Kabbanhalli are some bands of hornblendic schist with secondary augite and calcite modifications. An ultra-basic mass was also observed. It had altered into ferruginous material, wherein the carbonates of Fe, Mg, and mostly Ca, as kankar, had been developed.

Trig. Station 2766 north of Bettadpur is formed by an isolated "boss" of basic charnockite. Its general trend of north-west to south-east is distinctly oblique to the gneiss and hornblende schist and certainly suggests its connection with the main masses of charnockite found further east.

Eastern Section.

The striking feature of this portion of the country is largely due to the presence of hypersthene-bearing rocks. These probably represent apophyses and basic intrusives from the main mass of charnockite found more east.

3. SHEET No. 81 (69).

This is the southern continuation of the sheet just considered and represents the country lying between the same east longitude, but between $11^{\circ} 35'$ and $11^{\circ} 45'$ north latitude, and comprises an area of about 270 square miles.

The country is hilly with thick Elephant-forests known as Berambadi and Bhandipur State Forests.

Physical features. The highest peak recorded is $\Delta 4770$, which marks the position of the temple. The hill with this temple, which is not shown on the map, is well known as the sacred "Gopalaswami betta." A stone inscription showing the date of the Survey has been erected by the officers of the Topographical Survey near Trig. Station $\Delta 4769$.

Gopalaswami betta shrine.

Other conspicuous heights are $\Delta 4592$, 4519 and 4752 app.

The lowest point registered is 1,349 feet app. near the confluence of the Somati Holê and the Moyar river. Hence the greatest vertical height is 3,421 feet.

The principal rivers are the "Nugu" on the west, "Moyar" in the south and "Somati" on the east.

Natural drainage.

These natural landmarks are profitably made use of as indelible political boundaries.

Nugu river with its tributary Mavinahalla divides Mysore from Malabar on the west and south-west respectively.

Boundaries of the State.

Kaganholê joining the Moyar divides Mysore from Nilgiris on the south, and Somati Holê separates Mysore from Coimbatore on the east.

Here the greatest breadth from east to west of the Mysore State is about 30 miles.

After what has been said in the foregoing pages, very little need be mentioned under this head, except a few remarks regarding the granites and gneisses.

Geology.

The prevalent variety is the light-coloured biotite granite, crushed or perfectly gneissosed; sometimes so intimately silled and subjected to lateral pressure that it looks like a finely-banded, fissile gneiss.

Granites and Gneisses.

A very good example of this last type was observed on low ridge half a mile south-west of Jakanhalli, where the outcrops are striking east and west and dipping about 70° to the south. Here the pressure must have acted from north and south.

Jakanhalli fissile-gneiss.

Another instance can be seen along the track going down the steep hill side into the river Moyar from 2,519 app. to 1,682 app.

Here the gneiss is a complex with parallel acid and basic garnetiferous bands and intruded by a coarse granite, which is also invaded by pegmatites and aplites of still later origin and which has subsequently acquired a pretty mylonitic structure.

Younger coarse granite.

Near the bed of the river the rocks dip 70° to 80° right (south) and strike almost due east and west.

On hills south-east of Karekalbetta and north-west of Bhandipur respectively, and also on ranges of Upkarabetta and Yethunubetta, aplitic or quartzofelspathic granite makes a feature.

Aplitic or Quartzofelspathic granite.

This may be a phase of the light biotite granite in which the ferro-magnesian constituent is largely suppressed.

In stream south-west of Kaganholê P. S., a massive exposure of pink and gray granite with dark streaks was observed. Here the pink member appeared to be intrusive, while the whole mass evidenced to the fact that movement had taken place during consolidation or subsequent period of intrusion and pressure.

This pink granite has been found in a few more cases veining the light boitite granite, and in the bend of the stream north-east of $\Delta 3381$ app. it is distinctly intrusive into a mass of epidiorite.

Intrusive pink granite.

The two bold massifs of uniform pink granite south-east of $\Delta 4769$, which appeared to be uncommonly like more recent than the rest of the granite, may be related to the above.

Besides the above, the complex is characterized by bands of "Quasi-charnockite."

4. SHEET No. 111 (70).

This includes the country lying between 77° and $77^\circ 30'$ east longitude and between $11^\circ 45'$ and 12° north latitude, and comprises an area of 225 square miles, roughly.

The eastern portion constitutes the magnificent Biligirirangan range of mountains, which attain to heights of 5,814, 5,780, and 5,091, etc., feet, close to which the political boundary dividing Mysore State from Coimbatore "Zilla" passes.

Physical features.

The elevation, climate and soil appear to be favourable for the cultivation of coffee which was in a very flourishing condition on the estates of Attikan, near Trig. Station 5814, and Bedguli, which is about four miles south of the above point.

Attikan and Bedguli Coffee Estates.

The forests are thick and well wooded. Green grass grows luxuriantly and would make excellent hay.

Elephants, bison and tigers and sambar are not scarce.

The great feature of some of the peaks is their rounded, smooth character covered with verdant grass.

Trig. Station 4724, known as Thumbibetta, may be cited as a magnificent example of a lovely green smooth hill-top.

The soil capping the hill-tops and slopes is often many feet thick and is on the average dark or reddish. It is more basic than the ordinary granitic soil. This is evidently due to the more basic character of the

Evidence of great denudation.

charnockite granite, which must have been exposed to long period of uninterrupted subaerial denudation.

The western section is occupied by a low-lying fertile tract of country, which is drained by the river Suvarnavati.

The latter receives many subsidiary mountain streams during its meandering course.

The western part is composed of biotite gneiss, while the eastern is made up of massive charnockite.

Geology.

The junction between these two is anything but satisfactorily defined. It is certainly not regular. From what has been observed on the field and from a glance at the mapping of these two series, I think that the former is older than the latter, because the biotite gneiss appears to lie in the charnockite mass as lenticular inclusions, comparable to Zenoliths; and also that the marginal bands of charnockite look like "apophyses" and "tongues" that are in the nature of bifurcating masses.

Moreover near "4" of $\Delta 2743$, there is evidence that the basic charnockite is in contact with the gneiss and is breaking across the foliation strike of it (gneiss).

However, confirmatory evidence is very badly wanting to make any definite statements.

Intrusive into the gneiss and normal charnockite are runs of finer-grained basic charnockite granulites.

Finally the whole formation has been traversed by some huge dolerite dykes in a W. N. W. and E. S. E. direction.

Along the river bed earth-salt has been largely worked for, as evidenced by the "workings," which could not have been very old. The villages, where these workings have been carried on, often end in the suffix "Mole," *e.g.*, Kodimole, Dodmole, etc.

Earth-salt along the river bed.

The general strike of the charnockite series is about 10° east of north and the dip is very steep 70° — 80° east.

Strike and dip.

5. SHEET No. 110 (62).

This is the northern continuation of the previous sheet and varies by 15' north latitude only. It includes parts of Chamrajnagar, Yelandur and T.-Narsipur taluks and Coimbatore district.

The political boundary dividing the Mysore State from the Coimbatore district appears strikingly irregular and zig-zag.

Charnockite series forming the Biligirirangan range continues
Geology. north in the direction of Sivasamudram.

On hill 2662 no less than six distinct outcrops of dolerite dyke are running W. N. W. and E. S. E. They are probably of the same composition and age.

The geology of the rest of the country is similar to that of the previous sheet except that hills 2413 and 2403 are composed of a thin belt of schist, which pinches out before getting to 2179.

The general strike and dip continue the same as were observed in the previous sheet.

"SECTION B."

Petrographical Notes.

I. Hornblende granulite schist.

Since the inception of geological survey-work, various views regarding the origin and age of the Kolar schists of the Dharwar system have been expressed in the different records and memoirs published by the Mysore Geological Department.

Though their origin as a metamorphosed series of basic lava
Resume of Literature. flows has now been generally accepted, still their relative age and stratigraphical position to the surrounding granitic-gneisses remain yet to be solved.

Dr. Smeeth considers the granitic-gneisses intrusive, hence younger, towards the Kolar schists, though he does not deny the possible existence of "a gneiss" which may be older, while Mr. Wetherell has divided the Dharwar schists into two distinct series belonging to two distinct ages. He considers the Javanhalli

schist belt to be of the same age as the Kolar schists and the Chitaldrug belt as younger.

Further he makes the Javanhalli schists composed of four different "flows" of different composition and lying on an older archæan fissile gneiss.

The rocks representing these flows are understood to occupy definite stratigraphical positions. In the order of priority these are:—

Tarurite, Quartzite or Quartz-rocks.

Hornblende schist and Eclogite (*vide* Records, Volume V, page 23) which has been commented upon by Dr. Smeeth in the above volume on pages 23, 24 and 25.

During the field-season of 1904-05, Mr. Wetherell joined me in the neighbourhood of Malvalli and found in a narrow belt of hornblende schist running north and south of 2408 the presence of his typical "tarurite." He also recognised and mapped some similar exposures round about Huliurdurga, which he considers as the typical lower beds of the Dharwar system (*vide* page 3, Records, Volume VI).

I examined very carefully the above exposures to find out if this tarurite differed in any way from a great many similar exposures, which had previously been familiar to me; and whether the rock was a distinct member always occupying the lowest place in the schist series.

**Tarurite outcrops in
Malvalli and Kunigal
taluks.**

I think that the rock merely represents a local modification of the hornblende schist and does not occupy any definite position in the schist series. When a bed of hornblende schist is in junction with granite or acid veins, the contact-zone is often characterized by this secondary-augite rock.

I have found the rock distributed in the Kolar, Bangalore, Tumkur and Mysore districts. Its distribution is very irregular and exposures show great variations in composition and extent; but the change is always one of degree and not one of kind.

In fact the rock has no distinct petrological existence and thus cannot establish any stratigraphical position in the series. It is

interdependent on the pre-existence of hornblende schist and intrusive acid and granitic material.

A glance at Mr. Wetherell's map (Plate I, Records, Volume V) shows clearly that the tarurite exposures are irregularly distributed. They are not only underlying the hornblende schist but are scattered in the body of it, and are also included in the intrusive granite.

The interesting feature is their occurrence between hornblende schist and intrusive granite and their close proximity to quartzites or quartz-rocks.

The granites and quartzites are considered by Mr. Wetherell as intrusive towards the schists; but he has not made any mention of any contact effects or mineral or structural changes, which one would naturally expect to find, accompanying such intrusions.

Leaving for a while any further consideration of this "tarurite," I will go back to the hornblende schist.

Many of the specimens from the main mass of the Kolar schist belt and those lying in the granites and gneisses immediately round have been examined and described by Dr. Smeeth in his Bulletin No. 3, in which he expresses a hope to find further information regarding the secondary origin of pyroxene and granulitic texture from a study of granulites scattered throughout Mysore.

I have examined a considerable number of thin schist belts and patches, which are petrologically and stratigraphically similar to the Kolar schists.

They are invariably granulitic in texture, which has been secondarily brought about by large granitic intrusions. They are not infrequently associated with aplites, garnetiferous pyroxene-hornblende dykes and hypersthene-bearing acid and basic rocks, in which the granulitic texture to a very large extent is acceptedly an original feature.

But the granulitic texture so constantly found in schists outside the confines of the Kolar schist belt appears to be essentially due to the influences of masses of intrusive granite (*vide* Bulletin No. 3, page 49).

The schists found outside the Kolar schist belt may be described under divisions (a) and (b).

(a) Hornblende granulites.

(b) Pyroxene-hornblende granulites.

The hornblende granulites may again be sub-divided into—

(1) those containing sphene,

(2) those containing sphene and ilmenite,

(3) those containing ilmenite.

According to Dr. Smeeth's line of argument, sub-divisions 1 and 2 would warrant an inference that those rocks have gone through the condition of secondary pyroxene granulites, in which the secondary augite had completely reverted to hornblende,—a case of treble transformation of the original augite; while sub-division 3 would indicate that the rock had never passed through such a state, but that it is merely a crushed recrystallized hornblende-schist.

There is ample evidence that the above series has largely developed augite, sphene, etc., along acid and granitic intrusions; and instances also have been noted where no such secondary effects have been brought about by such intrusions.

A few specimens may be cited in support of the foregoing statements.

(a) Hornblende granulite.

(1) and (2). Those containing sphene and ilmenite are

J₂/ 249, 375, 575, 604, 631, 633 and 635.

J₂/ 249. From easternmost outcrop five furlongs south-east of

Locality.

Kenkahalli in Malvalli Taluk.

This occurs as a dark hornblende rock resembling the diabase

Description.

schist of the Kolar series more than the neighbouring granulites.

In this rock ilmenite has partially been converted into sphene. It is west of a tough, pyroxene band (J₂/248) which contains augite, much clinozoisite, clear sphene and apatite.

J₂/375. About one furlong south-east of (e) in Bandhole,

Locality.

Krishnarajpete Taluk.

This is not far from intrusive granite and shows traces of
Description. augite, titanite and much epidote.

J₂/575. From rise about two furlongs or so S. S. E. of Δ 2316,
Locality. Nanjangud Taluk.

The rock in texture is somewhat coarse. It shows fuzzy look-
Description. ing titanite and clinozoisite.

J₂/604. From outcrop north-east of Na-
Locality. ganapur south-west of Nanjangud Taluk.

Dark hornblende granulite which is apparently including gneiss.
Description. It shows sphene and apatite.

J₂/631. South of Δ 3249. (Alattur area).
Locality.

The rock is of a coarse-grained texture, more like a diorite.
Description. It contains sphene.

J₂/633. From the north-western flank of hill nearly due
Locality. east of Nyane katte.

Fresh looking rock with sphene and clino-
Description. zoisite.

J₂/635. From southernmost point (Nyane-
Locality. katte area).

Like the Kolar schists. It contains grains of sphene and
Description. clinozoisite.

3. Those containing ilmenite are J₂/281, 307, 322, 325, 373,
 374, 428, 890.

J₂/281. North-eastern spur of hill Δ 2399
Locality. (Huliyurdurga area).

Compact hornblende schist. Under the microscope its slice
Description. presents a vein of coarser crystallization in the
 centre, on either side of which is a medium-
 fine-textured granular admixture of hornblende, felspar, quartz,
 ilmenite and apatite.

J₂/307. In bend of stream due 20° W. of
Locality. N. of X. Hundalkuppe.

The texture of the schist is medium coarse. It contains ilme-
Description. nite, apatite and epidote.

Locality.	J ₂ /322. Near (y) of Yemmabetta (Kunigal Taluk).
Description.	Fissile fine hornblende schist with ilmenite.
Locality.	J ₂ /325. In nulla north-east of (a) in Up-parhalli.
Description.	Fine dark hornblende schist with ilmenite and apatite.
Locality.	J ₂ /373-374. Three furlongs S. S. E. of Δ 2680 (Krishnarajpete Taluk).
Description.	Similar to the Kolar granulites with ilmenite.
Locality.	J ₂ /428. About 1½ furlongs N. N. W. of Bilikere T. B., Hunsur Taluk.
Description.	Hornblende granulite with ilmenite and calcite shows affinities to altered dykes rather than altered schists.
Locality.	J ₂ /890. On the northern flank of Δ 2513.
Description.	Hornblende granulite without the tough bands which are augitic. Slice shows ilmenite and apatite.

Pyroxene-hornblende granulites.

Without a pre-knowledge of the secondary origin of the pyroxene and granulitic texture in these rocks, they would be compared to the basic granulites of the charnockite series or to the saxon granulites.

This strong evidence of the secondary origin of the pyroxene and granulitic texture, which are constantly accompanied by subsidiary sphene and other minerals, affords invaluable and indispensable aid to separate the altered Kolar series from similar-looking members of the charnockite and other igneous rocks, which are sometimes very intimately associated with one another in the field.

The following specimens, which on the field have all been recognized and mapped as belonging to the schists of Kolar series, when studied under the microscope, do not all present characters peculiar to the above. They are J₂/164, 172, 242, 330, 375, 554, 577, 623, 624, 688, 844.

Of the above those containing augite and sphene would naturally be grouped under granulites genetically related to the Kolar schists. These are J₂/330, 375, 577, 624 and 844, which need no further consideration except J₂/577 and J₂/623.

J₂/577 is a crushed veined portion of the hornblende granulite J₂/575; the latter contains no augite but sphene, while the former shows augite, sphene, clinozoisite and calcite.

If the presence of the sphene in J₂/575 is taken as evidence to the presumable existence of secondary augite, which has again completely reverted into hornblende in the rock, as already described, then the presence of augite due to acid veins in J₂/577 may be looked upon as a further transformation of the reverted secondary augite into hornblende in J₂/575.

In other words the hornblende representing the reverted secondary augite in J₂/575 has once more been changed into a tertiary augite.

Tertiary Augite.

But should the augite in J₂/577 be only secondary, the presence of sphene in J₂/575 would not conform to the above line of reasoning.

In all this only the changes undergone by augite and hornblende are considered. It would be very interesting to know if the secondary sphene so persistently accompanying the secondary augite has also followed its associate in reverting to ilmenite.

In such an event the distinction between hornblende granulites that have passed through a condition of pyroxene granulites and those which are merely crushed and recrystallized hornblende schists, would cease to exist.

Much more reliable information about various points is wanted before arriving at any dogmatic conclusions.

The remaining few specimens J₂/164, 172, 242, 554, 623 and 688 may next be considered.

J₂/164, 172, 242. These specimens were obtained from the neighbourhood of Maddur ferruginous outcrops, with which they are closely associated.

They are composed of pale green augite, hornblende, feldspar and quartz with ilmenite and apatite.

The presence of ilmenite to the complete exclusion of sphene is remarkable and would be unintelligible but for the fact that we have here some ferruginous members belonging to the charnockites.

Hence they are probably related to the charnockite series and not to the schists, though no recognizable hypersthene seems to be present.

But the absence of hypersthene is not to my mind such a great objection as the presence of sphene in the charnockites, for these contain hypersthene in varying quantities—from sections showing considerable proportion of hypersthene to others indicating hardly any— while sphene is typically absent.

J₂/554. Comes from a rise two furlongs W. S. W. of Marsarhalli Koratagere area, Tumkur Taluk.

Compact hornblende rock which has been veined and spotted with quartz. There appears a little augite in the slide and ilmenite and apatite. Here the augite may be original and the rock probably belonging to an altered basic intrusive.

J₂/623. This rock occurs as a band in the crushed metamorphic gneissic area south of 'V' formed by the Nugu river (neighbourhood of Sargur). It contains clinozoisite but sphene is not discernible.

J₂/688. From a point along C. Bargi track bearing 60° to

Locality. Δ 3231 Jainbetta.

Pyroxene-hornblende granulite. This resembles the granulite dykes in composition and structure.

Contact types.

Banded, veined and penetrated types of the hornblende and pyroxene granulites are frequently observed along contacts and junctions between the acid and granitic intrusives with the above schists.

A very large number of specimens in my rock collection pertains to this series. In this the augitic outcrops recognised by Mr. Wetherell as "tarurites" in the neighbourhood of Malvalli and Huliurdurga have been included.

Detailed descriptions of these examples will be too tedious and are not necessary after the foregoing considerations.

They will be grouped and enumerated under the following types.

I. Reconstructed rocks.

Owing to considerable interaction between the hornblende schists and the intrusive acid and granitic material, intermediate types less basic than the invaded schists and more basic than the invading acid and granitic rocks have been brought about. In many instances "lit-par-lit" injections have taken place, wherein the invading and invaded rocks can be recognized to possess their original distinctive character.

In some cases the invading rocks appear to have completely fused and recrystallized the hornblendic material of the schists and are found as distinct intermediate granites, whose derivative character is nevertheless identifiable as such by a study of their mineral and structural peculiarities.

Granitic Phase.

In the neighbourhood of Nagamangala and Honakere, some good examples of composite pyroxene gneisses are referred to in my previous year's work (Records, Volume VI, page 49).

Specimens J₂/344, 345, 429, 686, 277, 278, 289, 334, 343, illustrate the above type.

In the same Records, Volume VI, on page 51, I have suggested a field-term "Pseudo-charnockite" to include a new type of granite. Subsequent observations have induced me to classify specimens J₂/356, 357, 364, 368, 372, 382, 389 and 424 which belong to the above area under this heading.

Basic Phases.

As local modifications of the hornblende granulite schists, these occur as tough augitic bands, sometimes as highly folded, crumpled and dislocated outcrops, and occasionally as large lenticular bodies, in which coarser crystallization and concentration of secondary minerals have developed along pegmatitic and quartzose injections.

The composition of these rocks varies from point to point and specimens from the same outcrop may be obtained to show marked differences in mineral association. But throughout the whole series, an unmistakable family relationship or consanguinity can be established.

The minerals characterizing the series are hornblende, augite, feldspar, quartz, sphene, clinozoisite, scapolite, apatite garnet, calcite, pyrites and graphite.

Types in which one or more of the above minerals play a conspicuous role may be enumerated, as follows :—

- (a) Those containing hornblende, augite feldspar, quartz, sphene, epidote and apatite in normal quantities are J₂/181, 198, 277, 278, 289, 294, 317, 331, 376, 377, 429 and 471.
- (b) Those in which augite and sphene are conspicuous are J₂/204, 219, 235, 236, 239, 248, 250, 255, 272, 321, 510, 521, 525, 528, 551, 553, 576, 577, 590, 593, 628, 667, 709, 721, 722, 785 and 805.
- (c) Similar to above, where scapolite and sphene are prominent, are J₂/189, 201, 202, 276, 304, 596, 664, 715, 723, 724, 759, 764, 793, 794 and 877.
- (d) Rocks in which calcite and garnet are dominant, are J₂/241, 241 a, 271, 298, 302, 436, 582, 583, 616, 632, 665, 680, 716, 717, 725, 736, 737 and 815.

II. Quartz-reefs and Quartzites.

(Acid Intrusives.)

On page 11 of the first Edition of the Ore Deposits, which is a discussion republished from the "Engineering and Mining Journal," New York, May 1903, the following excerpt appears in the Editor's review :—

"Before this interesting controversy occurred, Mr. J. E. Spurr in his examination of the Yukon district in Alaska had become impressed with the evidence of ore segregation afforded by a series of closely related rocks in the Forty-mile region. In his report published three years ago, he announced a radical departure from

accepted views by describing the gold quartz vein of the Yukon as the end-product of rock segregation. This he explained as the result of progressive increase in silicification by means of which a basic hornblende granite passes into a quartz-felspar rock, termed alaskite; the changes continuing until the alaskite resembles a quartzite and is only distinguishable from a typical quartz-vein by small porphyritic crystals of felspar. Mr. Spurr holds that certain gold-bearing quartz veins in the Yukon have originated by a process of magmatic segregation and that they represent merely the siliceous extreme process, the final stage of which is marked by a magma so attenuated as to be described as highly heated water heavily charged with silica and other mineral matter including gold."

In various parts of the Mysore State we have evidence that the quartz-reefs and quartzites behave similar to the alaskites and quartz-reefs of the Yukon district.

A few typical examples are cited in support of the existence of alaskites.

In the neighbourhood of Koratagere, Tumkur District, very instructive cases have been exposed, wherein the genetic relationship that exists between the granitic phases and the quartz-reefs is strongly suggested.

Alaskites of Koratagere area.

On either side of $\Delta 2677$ is a fresh looking intrusive granite, J₂/500, characterized by pink felspar and blue quartz. The pegmatites (alaskites) and quartz-reefs also contain the same felspars and quartzes, though in varying proportions.

On page 55 of our Records, Volume VI, a reference to the above has been made. It may be supplemented by the enumeration of the following specimens, which were obtained from that area:—J₂/472, 474, 474a, 481, 484, 488, 491, 499, 504, 505, 506, 507, 511, 519 and 551.

Dr. Smeeth has described on page 41 of his Bulletin No. 3, a few specimens S₂/235, 268 and 279 obtained from trenches on the South Amble mining block.

Alaskites of Nanjangud area.

Similar quartz-veins or reefs containing tiny felspar crystals which are sometimes idiomorphic or oval, have been observed in different localities.

1. Between the two nullas on the north-western spur of $\Delta 3258$, there is a good exposure of quartz-felspar reef, $J_2/588$, which often merges into a quartzite of indifferent colour and gritty texture. It is further characterized by a ferruginous staining which coats the tiny holes resulting from tumbled-out sites of felspar and parallel and prismatic partings.

2. In going from Malhalli to hill west of Hospur, I observed quartzite with green mica forming the western portion of the outcrop, which to east passed into a quartz-felspar reef.

This quartz-felspar reef has been intruded by granitic material near a point on ridge bearing E. S. E. of Manchahalli. The banded weathering and crumpling of this rock, $J_2/640$, is very characteristic. Some parts of the reef contain garnets and pyroxene, though in much smaller proportions than in the garnetiferous-pyroxene-hornblende bands $J_2/641$. In contact with basic bands it results in ferruginous weathered types, the iron-oxides of which are evidently due to the breaking-down of the ferro-magnesian silicates.

The dip of the reef is very steep, perpendicular almost in places, and 60° — 70° to the west on an average.

3. In nulla $1\frac{1}{2}$ furlongs W. N. W. of Hundipur, there is good evidence of a quartz-reef with blebs of white felspar having intruded into some hornblendic mass and thereby resulting in a quartz-augite rock with sphene.

Besides the above, the quartzite bands peculiar to the charnockite series and some portions of the gneissic complex observed in Gundlupet and Chamrajnagar Taluks are characterized by fluidal and mylonitic structures. They are frequently found breaking across and banding the ferruginous members of the charnockite series, when they show phenocrysts of glassy sanidine. They graduate from grey chertose-veins to banded and contorted quartzites.

The following specimens— $J_2/192$, 228, 230, 773, 804, 818, 884, 889 and 893 illustrate the above characters.

III. Ferruginous and Quartz-ferruginous schists.

All the ferruginous formations that I have observed in the districts of Kolar, Tumkur, Bangalore and Mysore appear to be

genetically related to some basic member or other belonging to different petrographical igneous rock series.

With the possible exception of some iron-ore bodies appearing as veins or magmatic segregations, the rest may be grouped under a number of petrical types, as follow :—

(a) CUMMINGTONITE-GARNET TYPE.

In the neighbourhood of Maddur and Halagur, a number of outcrops of this type has been observed and referred to on page 44, Records, Volume VI.

Also a strong development of grunnerite and cummingtonite ferruginous rocks has been noted on Yemmabetta range of hills in the Kunigal Taluk.

The following specimens show cummingtonite, garnet, iron-oxide and sometimes quartz :—

J₂/159, 161, 165, 166, 171, 178, 229, 287, 301, 303, 315, 316, 527, 682, 739, 740, 778 and 787.

Most of the above contain remnant plates of pyroxene, which evidences the fact of having given rise to cummingtonite garnet and some iron-oxide.

One typical slide may be described.

J₂/287. In the main branch stream west of the bend in river due east of a village north of Honmachanhalli, Kunigal Taluk.

Locality.

Description.

A lustrous bluey-gray pyroxenic rock.

It is composed of large plates of remnant pyroxene lying in a mass of cummingtonite, garnet and some iron-oxide.

There is strong microscopical evidence to suggest that the rock was originally a pure pyroxenite, which has been subjected to dynamo-metamorphism. A few of the remnant pyroxene crystals have their continuity interrupted and show along their sheared planes a crushed debris of cummingtonite; while much of the original pyroxene has been changed into areas of cummingtonite. During this mineral transformation garnets and iron-oxide have been formed as side-products, the former

Cummingtonite derived from pyroxene.

lying poikilitically in cummingtonite areas which polarize in brilliant tints set off by the lamellar twinning so characteristic of this mineral. Some of the iron-oxide may be original.

(b) ECLOGITE TYPE.

Outcrops of this type sometimes present a very rich superficial ferruginous weathering. Specimens on breaking open often show green pyroxene, garnet, quartz and iron-oxide.

The following $J_2/162$, 263, 649 and 695 are characterized by sphene, calcite and epidote and are probably silicified modifications of hornblende schist, while $J_2/856$ is in the body of the charnockite series and consequently does not contain any sphene or calcite.

(c) CHARNOKITE TYPE.

Specimens of this type are composed of hypersthene with often hornblende and augite, iron-oxide (ilmenite and magnetite), apatite and quartz; very rarely feldspar.

They are $J_2/163$, 166, 167, 179, 216, 220, 222, 223, 234, 258, 263, 264, 796, 797, 848, 847, 866 and 867.

Some extremely interesting specimens have been classified under—

RARE-LAVA TYPE.

$J_2/227$, 265, 288, 742, 871 and 872 are modified greatly by the injection of banded, fluidal quartzose-rocks, already mentioned.

(d) EVEN-BANDED TYPE.

$J_2/168$, 177, 459, 611, 728, 754 and 780 illustrate the above type. They are composed of pyroxene, amphibole, quartz and iron-ore.

They probably belong to the age of Kolar schists and represent silicified portions of same.

(e) MAGNETITE-QUARTZ TYPE.

Here belong $J_2/170$, 179, 224, which may be related to the Kolar series or to the charnockites, like $J_2/179$.

(f) GRAYSTONE TYPE.

This is confined to the surface altered forms of the graystones and ultra-basics, which alter into ferrous hydrates and carbonates.

Some altered portions resemble ferruginous clays or lithomargic-looking bole.

Specimens J₂/615, No. 8061, J₂/444 and J₂/445 show a great proneness to such ferriferous alteration.

IV. Graystones and Schist.

Under this heading I include a series of basic and ultrabasic rocks which are characterized by their peculiar weathering into a dirty-gray to silvery-light colour with unctuous or soapy feel (Records, Volume VI, pp. 48 49, 50).

Nomenclature.

I have found these rocks in the neighbourhood of Hassan, Nagamangala, Krishnarajpete and in south-western portions of Nanjangud and Gundlupet Taluks.

Distribution.

Unfortunately in none of these areas do they form extensive schist belts, though their field and microscopic characters are sufficiently pronounced to throw light on their origin and relative age.

In Records, Volume III, Plate I., Mr. Wetherell has separated the dark hornblende schists from the gray schists which include potstones, talc, chlorite, tremolite, actinolite and ferruginous schists.

Literature.

Also on page 3 of Records, Volume VI, he says "There are no members of the upper series present on the hills, but a few isolated patches of chloritic, tremolitic or actinolitic schists and potstone occur here and there on the more level country."

The above references afford unmistakable proof that Mr. Wetherell considers the Nagamangala gray schists and the Kunigal isolated patches as parts of or similar to his Chitaldrug schists, which he is inclined to believe are of sedimentary origin. (*Vide* page 30, Records, Volume V.)

Mr. Sampat Iyengar is also willing to suggest such an origin to his Chitaldrug formation. (Records, Volume VI, p. 88.)

As I have not seen the Chitaldrug belt of schists, I cannot say how far such a conclusion may be correct or incorrect.

But the thin belt of schists occurring to the east of Nagaman-gala travellers' bungalow presents such a remarkable series of transition forms that their origin as derivatives of the massive rock cannot be doubted.

The massive rock is represented by J₂/323, which comes from the central portions of the outcrop. It is coarser than the edges, which are finer and quite schistose. It is locally porphyritic with dark-green crystals, which are presumably altered pyroxenes. The bulk of the rock is composed of secondary, fibrous blades and aggregates of amphibole.

A fresher portion of the above rock, J₂/324, shows a large amount of secondary calcite, besides the secondary ferro-magnesian, while J₂/327 contains olivine and pyroxene which have largely gone into secondary amphiboles, peculiar chlorite, calcite and iron-oxide.

Another slide made from a different portion of the above rock shows more calcite and less pyroxene with hardly any olivine, but a new mineral which may be 'humite,' 'chondrodite' or 'lavenite'—most probably chondrodite.

The finer modifications of the above resemble fissile hydromica schists and argyllites.

Such a massive rock containing pyroxene and olivine and secondary amphiboles, talc, etc., cannot be understood to have had anything but an igneous origin.

Nor can the strong field evidence which connects the massive igneous rock with its highly modified fissile schists and argyllites be ignored.

The fact that eruptives can present such transition forms is not unknown, as proved by Mr. G. H. Williams in his Classical Memoir on the "Greenstone schist areas" of Michigan.

Leaving the origin of these rocks aside, there is one thing that I should like to draw particular attention to, namely, the conspicuous paucity of acid and granitic veins traversing these massive gray-stones and schists.

By this I do not mean that the quartz-reefs and granites, which have penetrated the hornblende schists, have not intruded the

graystones; but I mean that they have certainly failed to penetrate these masses to the same extent and intensity as they have done into the former.

Where they have invaded them they are found in wide and solid bodies but never intimately banding them and seldom characterized by any secondary contact minerals.

This phenomenon is not only confined to the graystones but is peculiar to the massive amphibolites that occur in the neighbourhood of Bombay camp and Hæmatite quartzite ridges of the Kolar schist belt.

This proves that it is not altogether the difference between the relative ages of the Kolar schists and graystones that can account for such a phenomenon. Moreover there are hornblende masses much younger than the graystones that have been penetrated more intimately by granitic material.

The reason therefore seems to rest largely with the physical condition and composition of these rocks.

The graystones and schists are massive, tough and elastic bodies compared to the hornblende schists, which are fissile, hard and brittle.

Consequently lateral pressures and intrusive masses acting on these have produced different results.

These deforming agents have crumpled, puckered, altered and in a few cases penetrated the graystones, while they have crushed, dislocated and often intimately banded the hornblende schists.

This recalls to my mind a parallel case, which I observed while studying field-geology under the eminent geologist Dr. Peach in the neighbourhood of famous Glencoe Inn.

Here tongues of granite and porphyrite had penetrated the schist and quartzites, while the phyllites had been merely heaved, crumpled and minutely puckered.

Dr. Peach was of opinion that the phyllites owing to their tough and elastic properties had resisted and escaped the granitic intrusions.

These considerations may to a certain extent account for the striking scarcity of 'tarurite' and the curious behaviour of the dolerite dykes in the Chitaldrug formation.

Various specimens of this series may be enumerated as follows :—

GRAYSTONES.

J₂/323, 324, 326, 327, 328, 353, 355, 370, 371, 382, 450, 598, 599, 600, 603, 607, 645.

ALTERED TYPES.

J₂/362, 371, 425, 426, 426a, 449, 681, 711, 712, 713, 752, 792, 909.

In the above, the alteration often is so complete that the original ferro-magnesian have completely disappeared.

The slides now show areas of limonitic and ferrous hydrates which are traversed by irregular cracks that are infilled by carbonates of Ca and Mg and with chalcedonic quartz.

NEW TYPE.

J₂/442, 444, 445 and 447 are comparatively more acid and are characterized by the presence of more chlorite, calcite, Brunnerite, pseudomorphs of quartz after calcite, feldspar and schillerized plates of a ferro-magnesian mineral, probably pyroxene.

Besides the above, there are pyroxenites and amphibolites, which may or may not belong to this series.

These are "Pyroxenes with Olivine (altering)."

J₂/312, 450, 451, 594, 595, 603, 607, 645, 699, 746, 826, 883.

AMPHIBOLITES.

J₂/354, 612, 613, 614, 615, 648, 696, 697.

V. Charnockite Series.

In Records, Volume III, pages 198, 199, I have mentioned a few specimens obtained in the vicinity of Satnur. These represent granites and ferruginous basic members; both contain hypersthene, which was detected for the first time in Mysore rocks, except in some basic dykes.

A second mention about these hypersthene-bearing rocks is made on page 14 Records, Volume V, by Dr. Smeeth, who found the Biligirirangan range of hills mainly composed of charnockite series.

Again another reference has been made by me about these charnockites in Records, Volume VI, on page 45.

Here the Sivasamudram rocks are chiefly composed of acid and basic charnockites. They appear to be more crushed than the C. Bargur mass forming the Biligirirangan range and are intruded by the pink Clospet granite, which appears to be younger than the more banded charnockites.

I have also noted basic members of the charnockite series occurring in the garnetiferous biotite gneiss round about Frazerpet, and the hills past the toll-gate, dividing Mysore from Mercara, appear to be made up of charnockite members.

Dr. Holland notes the wide distribution of these rocks in Coimbatore, Salem, Madras, Nilgiris and Western Ghats.

The distribution of these rocks appears to follow the V-shaped configuration of the South Indian Peninsula ;
Distribution. and from the main masses apophyses and tongues seem to have protruded into the central portions.

For detailed petrographical considerations of these rocks reference may be made to Dr. Holland's Classical Memoirs, Volume XXVIII, Geological Survey of India, since my information on the subject is still incomplete.

At present I shall merely content myself by enumerating a list of specimens for purposes of reference under the following types, with brief notes.

NORMAL-ACID TYPE.

With the exception of altered and crushed phases, which contain more biotite and sometimes hornblende, the above type contains hypersthene, felspar belonging to the microcline and microperthite series, and quartz characterized by strain-shadows or undulose extinctions and thin fractures and dusty inclusions.

The accessory minerals are invariably ilmenite or magnetite and apatite ; sometimes zircon and epidote make their appearance.

The texture of the following specimens vary from medium-coarse to medium-fine and always show a granitic to granulitic structure.

J₂/194, 207, 209, 218, 350, 351, 413, 416, 676, 808, 846, 850, 852, 860, 864, 868, 870, 878, 880, 912.

J₂/850 is an aplitic phase and J₂/852 is the pegmatitic variation.

Intermediate type.

Here the ferromagnesians are often grouped in clusters and the accessory minerals are more abundant than in other types.

J₂/193, 208, 214, 217, 415, 416, 418, 671, 807, 822, 831, 838, 839, 853, 861, 865, 901, 904, 905, 906, 913.

Basic type.

In this the ferromagnesians and feldspar (chiefly microperthite) are in excess over quartz, which often is completely eliminated.

In a large number of cases hornblende predominates over hypersthene and green augite; apatite gets comparatively poor.

J₂/190, 191, 206, 210, 213, 221, 393, 395, 406, 409, 410, 412, 417, 434, 456, 458, 662, 663, 672, 673, 698, 700, 789, 799, 814, 824, 830, 832, 838, 857, 863, 869, 879, 899, 900, 914, 916, 917, 919, 920, 921.

Ultra-basic or Pyroxenite type.

Hypersthene, augite and hornblende with occasionally subordinate feldspar and iron-ore characterize this type. Now and then apatite has been observed and in one instance a chrome-spinel hercynite has been found.

J₂/215, 352, 400, 405, 438, 669, 677, 678, 679, 800, 813, 837, 840, 849, 873, 887.

Banded type.

In many localities the series is marked by banded structure, which is due to the existence of alternate light and dark or acid and basic segregated portions of the magma.

Two typical examples are described below.

J₂/834. On the northern side of Chamrajnagar-Hasnur road

Locality. and about two furlongs west of Punajur Lodge.

Specimen shows a band of light acid charnockite in contact

Description. with a band of dark basic one.

Both macroscopically and microscopically the contact is as sharply defined as the blade of a knife and perfect interlocking structures are preserved.

The melanocratic half shows the same texture as the remaining leucocratic half, and both are characterized by the suite of minerals peculiar to the charnockite series, though in varying proportions.

J₂/851. About 1½ furlongs to the 11th milestone on the ghat-road from Punajur to Attikhan.

Locality. Specimen shows the contact between the acid and intermediate to basic charnockite.

Description. Magmatic differentiation is well displayed by the slide, which resolves itself into two halves that obviously belong to one magma; one-half contains felspar and quartz while the other half is characterized by hypersthene, apatite and ilmenite, in addition to the above.

Apparently the accessory minerals do not seem to have been reserved for the final consolidation of the magma.

Acid intrusive type.

A mention has already been made of this type under Quartz-reefs and Quartzites.

J₂/198, 228, 230, 773, 804, 818, 884, 889, 893.

Basic-intrusive type.

This includes the hypersthene pyroxene granulites, which are precisely similar to the basic type, except that they behave like intrusive masses in the field and show a finer-grained texture.

J₂/217, 390, 391, 392, 393, 397, 398, 399, 402, 403, 404, 407, 410, 432, 435, 702, 718, 774, 814, 819, 823, 829, 833, 845, 843, 875.

Peculiar type.

A brief note will be made on specimens included hereunder.

J₂/835, 836, 841, 854, 855, 868, 869, 886, 922.

J₂/835-836. These occur north of road over three furlongs west of Punajur Lodge.

Locality.

They present a graphic intergrowth of green augite and hornblende with lime felspar. There is neither hypersthene nor quartz. J₂/836 is similar to J₂/835, bar that it contains more garnets besides.

Description.

J₂/841, 854, 855. Close to the bend of the ghat-road near the 4th furlong post of the 14th milestone from Punajur to Attikhan.

Locality.

These are comparable to the "trap-shotten" type referred to in Dr. Holland's Memoirs, Volume XXVIII, on pages 198 to 202.

Description.

In this area J₂/841 is near a basic dyke and I thought in the field that the latter had sent irregular tachylitic stringers into the charnockite.

Further south J₂/854 and J₂/855 had been evidently formed by an irregular injection of acid material which shades off from a light, hornstone-chert into a darker trapshotten kind.

Locality.

J₂/868. About three furlongs south-west of Kathedevargudi camp.

The specimen represents a good type of garnetiferous biotite-charnockite in which hypersthene is totally absent.

Description.

This locality, which was inspected by Dr. Smeeth towards the end of my field season, is strongly featured by a copious development of garnets, which are distributed throughout the different petrical types.

In the above pages I have omitted to introduce a garnetiferous type; for the simple reason that the mineral does not conform to any hard and fast line of delimitation.

There are acid, intermediate basic and ultra-basic masses, which are completely free from garnets; while the same types are characterized by its abundance in other localities.

Generally the mineral is more conspicuous in the "basic-intrusive type," "micaceous acid type" and "ferruginous-pyroxenite type."

There are a large number of slides which show that the presence of garnet with quartz or felspar is accompanied by a corresponding absence of hypersthene and augite, thereby suggesting its secondary origin from the above ferromagnesian.

Besides there are certain horizons or zones in which the mineral has been so largely developed to play an important role.

Though the origin of this mineral is largely secondary, in which case it is due to crushing, dynamo-metamorphism or varying temperature conditions to which the pyroxenic masses may have been subjected to, yet there are cases which suggest that the mineral may have existed as an accessory constituent of the magma.

Primary-breccia.

One very good instance of this phenomenon, illustrated on page 219 of Dr. Holland's Memoirs, Volume XXVIII, was observed on the southern and south-eastern slopes of Δ 2662 (Topo Sheet No. 110—New No. 62).

Here the normal and basic charnockites are found lying in between the different E. and W. dykes. The evidence of acid portions holding autoliths of basic schlieren or patches in rounded and ovoidal forms is very definite.

Corundiferous Zenolith.

The above has been referred to by Dr. Holland on pages 235 and 236 in Memoirs of the Geological Survey of India, Vol. XXVIII.

I examined the trench put down by Mr. Randolph Morris for obtaining the ruby-red corundum.

It is situated about two furlongs east of Badavadi and about twenty or thirty yards north of the stream. It runs parallel to the strike of the rocks which show 15° — 20° , and measured 10—12 feet long, 2— $2\frac{1}{2}$ feet broad and 4 feet deep.

The walls of the trench exposed solid black rock which is a crushed-banded garnetiferous pyroxene granulite, J₂/824, dipping steeply to the west.

No crystals of corundum could be found in the above rock, but many small ones were picked out from the disintegrated gneiss, which

must have originally occupied the lenticular worked-out zone of the trench. For, on examining the debris on top, I was fortunately able to find one or two large blocks of gneiss, which were studded with some fine rose-red crystals of corundum. J₂/825 is a specimen of this biotite-gneiss.

I made several washings of the adjacent stream in the hope of finding some clear water-worn crystals, but met with no success.

Dykes.

There are a few large E. S. E. and W. N. W. running titaniferous dolerites with chilled edges traversing the charnockite series; but felsite-porphyrries have made themselves very conspicuous by their absence.

Besides, the dark finer-grained hypersthene-pyroxene granulites are found running obliquely in the normal acid and basic charnockites. Their edges are not marked by any chilled structures. This fact has been understood by Dr. Holland as evidence of the injections having taken place while the charnockites were still hot.

Though there seems no doubt that the finer-grained basic intrusives are genetically related to the charnockite magma of a later period of consolidation, yet the absence of chilled edges does not appear to me to necessarily warrant such an inference; since many intrusive contacts between rocks of different periods of consolidation fail to show any such structures.

I should doubt if all dolerites and felsite-porphyrries evince chilled edges.

VI. Quasi-charnockites.

The specimens included under this group may be separated under two types.

(a) ACID TO INTERMEDIATE TYPE.

Both in the field and under the microscope the rocks belonging to this type resemble the charnockites. They however differ from the latter, in that they show no hypersthene, and from the "reconstructed rocks" or "intermediate granites" in that they contain no sphene.

They are composed of hornblende or biotite or both with felspar and quartz. The accessory minerals are invariably ilmenite and apatite and a little zircon. Garnets also appear very frequently.

The following are some of the specimens:—

J₂/589, 618, 619, 646, 647, 661, 686, 707, 729, 733, 734, 755, 765, 781, 788, 798, 880, 908.

(b) INTERMEDIATE TO BASIC TYPE.

The specimens of this type also show affinities with the corresponding types of the charnockite series. These are also devoid of any hypersthene, but are nevertheless free from any sphene.

Hornblende predominates in all the slides though augite is found in some. Ilmenite and apatite are constant; zircon has been noted and garnet is very prevalent.

J₂/636, 637, 638, 639, 650, 667, 690, 703, 708, 720, 732, 735, 748, 751, 779, 806, 824, 873, 881, 882, 885, 910 and 915.

Though the conspicuous absence of hypersthene in the above rocks deters one from unhesitatingly grouping them under the charnockite series, yet the constant association of ilmenite and apatite, even in the pyroxenic types, to the exclusion of sphene, suggests strongly such a family relationship.

If such is really the case, *i.e.*, if the above rocks should be genetically related to the charnockite series, then we have a large complex in which masses of charnockite must have been subjected to low temperature conditions, wherein hornblende has formed to the exclusion of hypersthene.

As a further proof that the series must be different to the reconstructed rocks or modified banded hornblende granulite schists, the following interesting specimens may be noted.

J₂/655, 656, 657 and 658. These were obtained from a place five furlongs south-west of Kandagal Hosur in Gundlupet Taluk.

They were mapped as light and dark bands probably related to the charnockite series and were found not far from hornblende granulite schist which is also forming the biotite-gneissic complex.

But their structural and mineralogical characters under the microscope are so unlike the charnockites and so like the modified schists that they must be correlated with the latter.

Absence of hypersthene and presence of sphene afford negative and positive objections to connect them with the charnockites.

Specific Gravity.

The density of a few specimens belonging to the different petrographical series has been determined on Walker's Steel Yard.

I. Hornblende-granulite-schist series.

- J₂/633. Garnetiferous hornblende granulite. Sp. Gr.=3·23.
- J₂/634. Contact type. Sp. Gr.=3·032.
- J₂/625. Hornblende granulite. Sp. Gr.=3·04.
- J₂/745. Similar to above. Sp. Gr.=3·101.
- J₂/709. Banded garnetiferous-pyroxene-hornblende granulite.
Sp. Gr.=3·037.
- J₂/721. Similar to J₂/709 but with fewer light bands and garnets. Sp. Gr.=3·083.
- J₂/722. Similar to J₂/709 but with fewer garnets and probably more of the lighter minerals. Sp. Gr.=3·0.
This result is as it ought to be.
- J₂/723. Scapolite-bearing type. Sp. Gr.=3·08.
- J₂/724. Calciferous-scapolite rock. Sp. Gr.=2·809.
- J₂/715. Garnetiferous pyroxene-granulite with scapolite. Sp.
Gr.=3·272.
- J₂/716. More calciferous with a little augite, garnet and quartz.
Sp. Gr.=2·77.
- J₂/717. Similar to above but with more augite. Sp.-Gr.=
2·923.
- J₂/736. Similar to J₂/716 but with less quartz. Sp. Gr.=2·75.

II. Quartz-reefs.












- J₂/740. Quartz-felspar (alaskite) reef with stained ferromagnesianes. Sp. Gr.=2·699.
- J₂/651. Quartz-reef; Blue-charnockite-series. Sp. Gr.=2·6.

III. Graystone series.

- J₂/648. Sp. Gr.=3·105.
- J₂/645. Do =3·0.

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		<i>Charnockite dykes— without chilled edges</i>		40'
		Quasi Charnockite		
		Ferruginous Rocks		
	P. V.	Gray-stones		
	C. G.	Ultra basics		
	F. G.	Quartzites & Quartz reefs		
	M.	Hornblendic dykes		
ite	I. C. G.	<i>Epidiorite dykes</i>		
	G. C.	<i>Dolerite dykes</i>		
e	C. C. G.	Earth Salt		
	Q. F.	Kankar		
10'				

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